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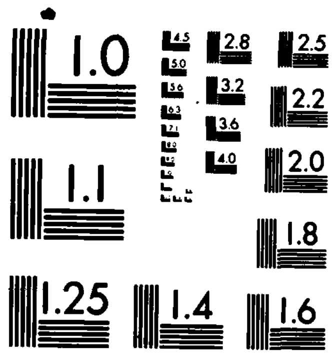

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IDA REPORT R-285

REPORT OF THE JOINT INDUSTRY - DoD TASK FORCE ON COMPUTER AIDED LOGISTIC SUPPORT (CALS)

Volume II: Report of Policy and Legal Constraints Subgroup

Frederick R. Riddell
Richard A. Gunkel
George Beiser
Siegfried Goldstein
Bruce Lepisto
Editors

June 1985

Prepared for
Assistant Secretary of Defense
Manpower, Installations and Logistics

IDA

INSTITUTE FOR DEFENSE ANALYSES
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In April 1984 the Institute for Defense Analyses was directed by OSD to assemble a task force of senior industry and government people to address the problems faced by DoD in attaining an integrated computer-aided logistics support system. The task force was given a charter to "develop a strategy and a recommended master plan for computer-aided
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logistic support." The task force was formed and held an intensive series of meetings during the last half of 1984 during which this report was prepared.

Volume I of the report gives a summary of the task force deliberations and lays out a recommended strategy and master plan that would, in five years, have in place all the elements needed for a complete computer-aided logistics support (CALS) system based on electronic data transfer. Volumes II, III, IV and V of the report were prepared by the subgroups that were formed to examine different aspects of implementing a CALS system. These volumes contain detailed information that supports the recommendations made in the Summary, Volume I.

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Contract MDA 903 84 C 0031
Task T-3-192

PREFACE

This report was prepared by the Institute for Defense Analyses (IDA) for the Office of the Secretary of Defense, Manpower, Reserve Affairs and Logistics Under Contract Number MDA 903 84 C 0031, Task Order T-3-192, "R&D Support to Improve Force Readiness."

The issuance of the report answers the specific task to "...assemble a group of both industry and government personnel...experienced in...computer-aided technologies for automation of support procedures in order to examine issues...include(ing) the subcontractor level, inventory management techniques, etc. At present these issues are being addressed individually without apparent consideration of their interaction in meeting the total DoD objective...to evolve a general plan for automated support of DoD operating systems which addresses the problems of interaction between the different systems now in use or evolving, and the various approaches being taken by DoD to address its readiness problems."

CONTENTS

POLICY AND LEGAL CONSTRAINTS SUBGROUP

Objective

To identify DoD and industry policies and existing planning standards (e.g., Mil-Std 1388-2A), relevant laws (e.g., PL96-511, Paperwork Reduction Act), and relevant regulations (e.g., DAR and FAR) which facilitate or constrain pursuit of the CALS strategy. The resulting list should then be grouped into generic categories and cross-checked with policy and legal issues evolving from the other subgroups in order to develop a set of recommended changes necessary to facilitate the CALS strategy.

Members

Chairman:	Herman Correale
Vice-Chairman:	Emerson Cale
Integration:	Howard Chambers
DoD/IDA:	Joe Arcieri/Bruce Lepisto
Members:	Neil Christianson Mike Deeter John Hull Kurt Greene Jim Laird Tom Mansperger Burt Newlin Dave Sherin

EXECUTIVE SUMMARY

Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) have widely computerized the design and manufacturing processes and provided extensive data bases. Computer-Aided Logistics Support (CALS) is the computerization of Integrated Logistics Support (ILS) processes. CALS links the activities of each ILS element, improves their interfaces with each other, with government departments, and with contractors. Integration of CALS, CAD and CAM data provides a relational data base that will serve logistics support planners over an entire acquisition program, beginning with the pre-concept phase and progressing through disposal. Ultimately, CALS will be implemented across all weapon systems and all military Services.

The mechanisms for supporting CALS implementation should include the data bases, computers, communications linkages, recording media, software and hardware necessary to provide compatibility among the participating contractors and military Services. This information network must be responsive to using activities including the System Program Office, logistics centers, government laboratories and using commands.

Interface standards are required to describe relational data base criteria for CAD, CAM and CALS. These standards would specify requirements for interchangeability, transportability and access management of digitized data. Interface standards should describe how discrete systems work with each other, rather than how to design and develop each element of the system. A Standard Strategic Program Plan is required to identify standardization opportunities and provide roadmaps for standards development.

Standards are also needed to define common terms and data elements for each ILS discipline. A DoD policy should require the establishment of a CALS standard that would act as an index and dictionary for data required for development, acquisition and post-production. A Joint industry/government team should be tasked to prepare the CALS standards.

Data access and file transfer is a policy issue to be resolved by DoD. The government needs to define the CALS logistics data requirements and integrate these with their existing automation systems. Policy for data transfer should assure that contractor files would not have to be recreated by the government. Access or acquisition of data bases is an open issue.

Programs exist or are under development for automating technical information. One of the foremost purposes of CALS is to focus these projects on enhanced logistics support through integrated computer-aided operations. DoD strategy should include development of selected CALS building blocks through the application of technology-related pilot demonstration programs. CALS policy should encourage program demonstrations beginning with IR&D/CR&D technology development. As automation of selected pilot program modules is achieved, interchangeability and transportability of digitized data will be demonstrated. An evolutionary approach will permit systematic progress development and integration of all required CALS building blocks. Field implementation of CALS will begin with new weapon system acquisitions and gradually expand to all weapon systems.

The present legal and regulatory environments generally encourage the rapid implementation of automated processes offered by CALS. However, the Paperwork Reduction Act, when literally interpreted, requires that all information collection requests be inventoried and displayed and control numbers and expiration dates assigned. Proprietary and software data rights issues have been highlighted as areas of concern to industry. Concerns for legal issues could be eliminated by a DoD policy for transfer of digital data.

GLOSSARY

ADP	-	Automatic Data Processing
ANSI	-	American National Standards Institute
CAD	-	Computer-Aided Design
CADD	-	Computer-Aided Design Definition
CAE	-	Computer-Aided Engineering
CAM	-	Computer-Aided Manufacturing
CALS	-	Computer-Aided Logistics Support
CDRL	-	Contractor-Furnished Equipment
CRAD (CR&D)	-	Contract Research and Development
DAR	-	Defense Acquisition Regulation
DDN	-	Defense Data Network
DLA	-	Defense Logistics Agency
DMSSO	-	Defense Materiel Specifications and Standards Office
DoD	-	Department of Defense
DoDD	-	Department of Defense Directive
FAR	-	Federal Acquisition Regulation
GFE	-	Government-Furnished Equipment
GKS	-	Graphics Kernel System
IGES	-	Initial Graphics Exchange Specifications
ILS	-	Integrated Logistics Support
IRAD (IR&D)	-	Independent Research and Development
ISO	-	International Standards Organization
LSA	-	Logistics Support Analyses
LSAR	-	Logistics Support Analyses Record
Mil-Std	-	Military Standard
NAPALPS	-	North American Presentation Level Protocol Standard
NBS	-	National Bureau of Standards
PHIGS	-	Programmer's Hierarchical Integrated Graphic Standard
SDRL	-	Sellers Data Requirements List
SGML	-	Standard Generalized Markup Language
VDI	-	Vertical Device Interface
VDM	-	Vertical Device Metafile

COMPUTER-AIDED LOGISTICS SUPPORT (CALS) POLICY AND LEGAL CONSTRAINTS SUBGROUP

A. CALS CONCEPT

1. General

Implementation of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) concepts will help reduce the efforts associated with designing and developing a new weapon system, as well as the development time from go-ahead to production delivery. Proper emphasis on weapon system logistics support is essential for sustained combat and peacetime operations and dictates that the data available in CAD/CAM be electronically coupled to a computer-aided logistics data base. This relational data base concept, in conjunction with advanced computer networks, presents opportunities to more fully automate and integrate the logistics support processes. However, before this can happen, a definite change in mind set is required.

The advantages of computer-aided logistics support are many and varied. As new data auditing and approval techniques become available, contracts for support material and services could be placed electronically, and data transfer from contractor-to-government and government-to-government agencies could be handled electronically. Reprocurement data would be immediately available, and program management decisions could be based on near-real-time data accessible to both government and contractor agencies. Currently, and in contrast, vast amounts of redundant data on current programs inundate the logistics community with paper and burden the logistics support community with attempting to find the "real" problem.

Inherent to the effective implementation of CALS is a clear understanding of what is required by the government. The CALS standards must include compatible data base construction and maintenance procedures to ensure uniformity of data elements common to more than one user. Also, the media used to transmit data must be specified. Mass common data deliverables may best be transferred by physically relocating discs or magnetic tapes possessing common data elements and data format. Frequent transfer of small numbers of data elements would be accomplished using on-line video display terminals. Maximum use of embedded software routines could be used to tailor repetitive reports to a common format.

2. Purpose of CALS

While CAD and CAM computerize the design and manufacturing processes by providing extensive digital data bases, CALS is the computerization of the Integrated Logistics Support (ILS) processes. CALS, coupled with the as-designed and as-built data available in CAD and CAM, will form a comprehensive, manageable data base containing all elements essential for enhanced logistics support. The CALS data base would become the "point of reference" for government and industry and serve all acquisition and logistics support agencies.

3. Objectives of CALS

CALS must take advantage of existing and emerging information systems technology to improve productivity and quality of the logistics support processes by (1) actively influencing the design process, and (2) automating the development, production, delivery and maintenance of the logistics support products and resources.

The CALS objectives are summarized as follows:

a. Improve product reliability, maintainability and supportability by influencing design through interaction between CAD and CAM.

b. Improve productivity by reducing manual logistic processes and thus reduce system flyaway cost.

c. Increase the effectiveness of logistics planning by permitting early identification of logistics support needs.

d. Improve the logistic support acquisition process and configuration management through integration of CAD, CAM and CALS information.

e. Ensure continued availability of current product definition data, etc., for follow-on support, configuration management, spares reprocurement and post-production support.

4. CALS Description

CALS would span the entire program life cycle beginning with the pre-concept phase and progressing through product disposal. Ultimately, it would be implemented across all weapon systems and all military Services.

As the following paragraphs illustrate, CALS ultimately should include logistic modeling, accounting, interdependency "trees" and analyses [particularly Logistic Support Analysis (LSA)].

CALS would apply to the full depth and span of logistics activities, that is, to all ILS element functions as defined in DoDD 5000.39. These include Supply Support; Technical Data; Facilities; Manpower and Personnel; Packaging, Handling, Storage and Transportation; Training and Training Support; Support and Test Equipment; Computer Resources Support; Maintenance Planning; and Design Interface activities including Reliability, Maintainability and Human Factors.

A function of ILS is to influence the initial design concept fo a weapon system so as to enhance supportability. In the preliminary design stage, the logistics data base needs to be linked to the product definition process (CAD), thus providing the basis for influencing the design, automating LSA and making logistics simulations assessments (refer to Figure 1). Alternative design approaches to the support concept will be considered based upon cost effectiveness tradeoffs. Given more "real time" availability of the results of logistics analyses, logisticians will have the opportunity to further influence the design, and the resultant design would be subsequently analyzed, via the LSA process, to determine the best mix of support resource requirements. The data elements required for the LSA process would reside in an ILS data base. The ILS requirements resulting from the LSA process would be available to develop the support resources through a series of computerized support element output modules.

The logistics data elements, residing in the ILS data base, would be as agreed upon by the government and the contractor, identified in the contractual CALS standard, and tailored to each specific program. Furthermore, these data elements could be electronically transmitted/called-up to user terminals. Such computer transparency permits other software applications such as automated technical manuals, training courses and program management plans.

The CALS data base would further provide the government with enhanced logistics support capabilities for the post-production phase. Technical information required for spare parts provisioning and modification efforts would be current and accessible. Maintenance of data files could be assumed by government agencies, as required, with no loss of essential data and without the expense of recreating a weapon system file.

CALS would require hardware, software and standards necessary to computerize all logistics support data and provide a compatible link among all government and industry users. Design, manufacturing and logistics data bases would have to be interactive (computer transparent) and mutually supportive. Interactive capability would ensure that selected data from CALS, CAD and CAM could be retrieved by all logistics support agencies as required. Mutually supportive programs would ensure current data.

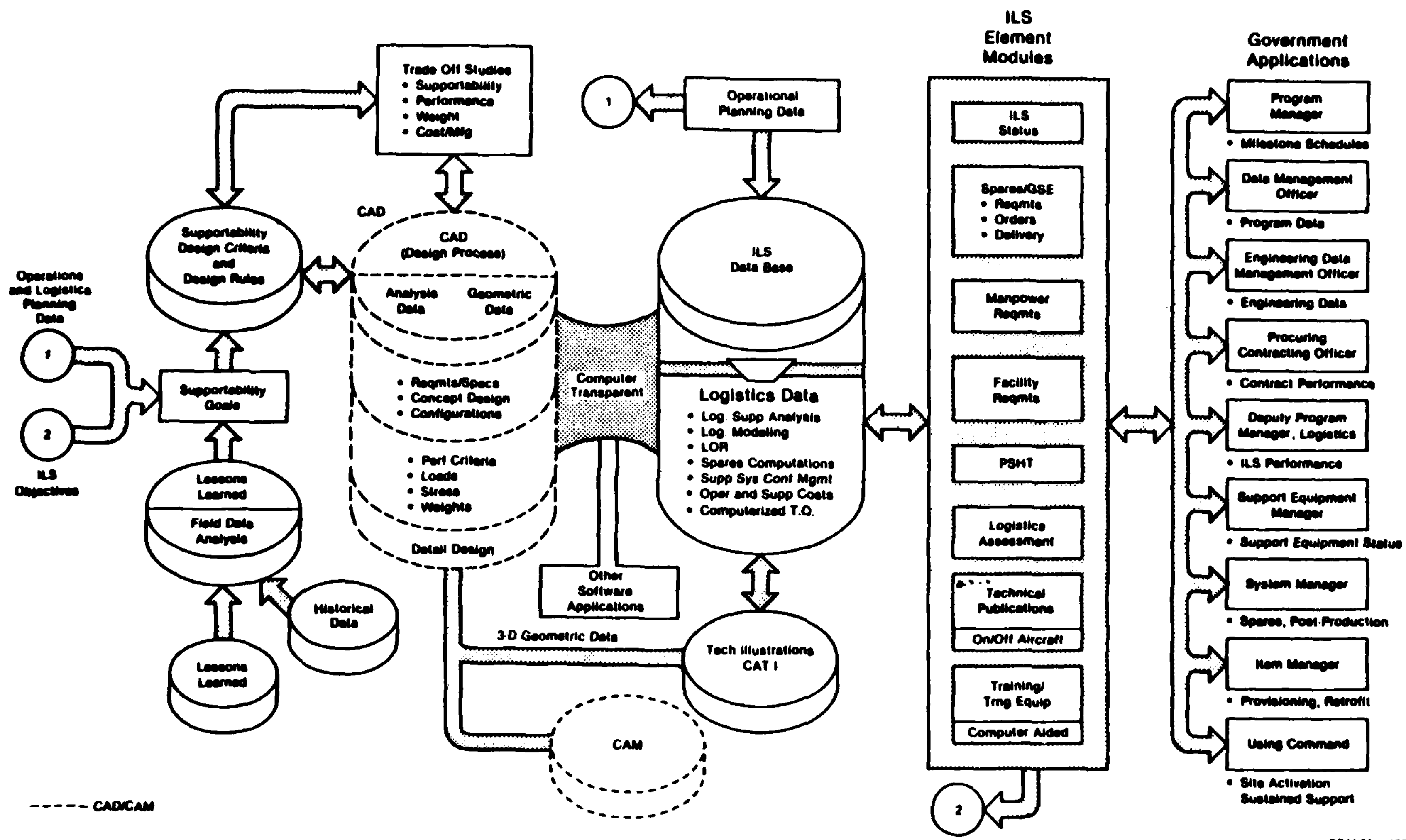


Figure 1. COMPUTER-AIDED LOGISTIC SUPPORT

Finally, CALS would not permit indiscriminant data changes. "Read only" or "write" capabilities would be attached to passwords to ensure security and accuracy of data. The computerized data, available to all users, could eliminate much of the hard copy report - ing required by today's CDRLs. Key principles of CALS are summarized in Table 1.

Table 1. COMPUTER-AIDED LOGISTICS SUPPORT KEY PRINCIPLES

- Logistic design criteria, including lessons learned and field data, must interact with the design data base (CAD) to influence design for supportability.
- Supportability design-to-criteria and design rules (algorithms) must be developed and must interact with CAD.
- Approved logistic support analyses must control publications, personnel, training, training equipment, support and test equipment, spares and facility requirements in CALS.
- CALS must contain real-time logistic support planning/scheduling information.
- CAD and CAM data bases should interact with the CALS data base.
- Source of CALS data must be computer-transparent to the user.
- CALS must have provisions for logistics modeling and O&S cost.
- CALS should be linked to customer field data reporting systems.

B. POLICY ISSUES AND RECOMMENDATIONS

1. Key Policy Issues

The key policy issues are as listed below:

(1) Near term and long range goals to achieve interoperability and interchangeably of electronic information do not exist.

(2) Existing policies do not support a minimum set of standards for acquiring and transferring electronic information to the government users.

(3) A standardized set of data elements for electronic information within the weapon system logistic support acquisition process does not exist.

(4) Policies do not encourage computer-aided techniques to improve integration of logistics considerations into the early stages of design.

(5) Although not a unique CALS issue, the proprietary data rights and acquisition of computer software is a CAD/CAM issue that will impact CALS. This is especially true when considering government access to contractor's CAD/CAM files.

(6) The access or acquisition of data bases is an issue to be addressed. The government should consider procuring information or access to information, not data bases.

(7) DoD policy issued 10 March 1983 states: "All DoD ADP systems and data networks requiring data communications services will be provided long-haul and area communications, interconnectivity, and the capability for interoperability by the Defense Data Network (DDN)." Logistics data traffic will be substantial and traffic priorities complex and many exceed DDN capabilities.

2. Policy Recommendations

a. General Policy Recommendations

The general policy recommendations are as listed below:

(1) DoD policy should establish digital data transfer as the preferred method for acquiring engineering drawings, technical manuals, and other weapon system acquisition support data.

(2) DoD should require the use of existing and emerging industry standards (such as IGES, SGML, GKS, VDI, VDM, PHIGS and NAPLPS) for accomplishing such digital data transfer wherever possible.

(3) DoD policy to actively promote development of digital data systems should be strengthened through revision of the DoD Instruction 5000.19 policy for management and control of information requirements.

(4) A joint industry/government team should be tasked to prepare a CALS standard.

(5) CALS policy should encourage pilot program demonstrations during IR&D/CR&D technology development.

(6) CALS policy should recognize the acceptance of alternate delivery media.

b. Standardization Strategy

It is recommended that a Strategic Program Plan be prepared by the Defense Materiel Specifications and Standards Office (DMSSO) to identify standardization opportunities and provide a detailed roadmap to develop standards needed for long range support of CALS initiatives, especially in the areas of data bases, data elements, communications, graphics and textual standards. The Program Plan for digitized information should identify ways and means to promote DoD's participation and support of efforts by voluntary standards organizations such as the American National Standards Institute (ANSI) and the International Standardization Organization (ISO).

c. Top Level Interface Standard

A high level standard for handling the exchange of electronic information and data such as ANSI's IGES and proposed SGML should be considered for adoption by DoD to

enforce future interchangeability and transportability of digitized information between Services, agencies, and contractors.

A top level MIL Standard on interfaces for digitized information is necessary to facilitate the acquisition and use of digitized data. Timely data access for government agency use is the major objective, not data base acquisition or real-time access to all information. Issues to address are as follows:

(1) Integration of various information program requirements and identification of major data repositories that can manage and maintain digitized data for each of the Services are required. This should include digitized information for ILS support as well as digitized data for product definition data, CAE/CAD engineering data, manufacturing data (CAM) and procurement data.

(2) Formal validation requirements and facilities for validating translators (compilers) need to be established to ensure transportability (interface) of the various data elements and to permit communication between the participants (industry and government agencies), as well as between CAE/CAD/CAM and CALS.

(3) The CAD, CAM and CALS standards are subset standards which relate to a top level interface standard for information transmission and access management (graphics and text). The general relationship of data base standards to the top level standard is illustrated in Figure 2.

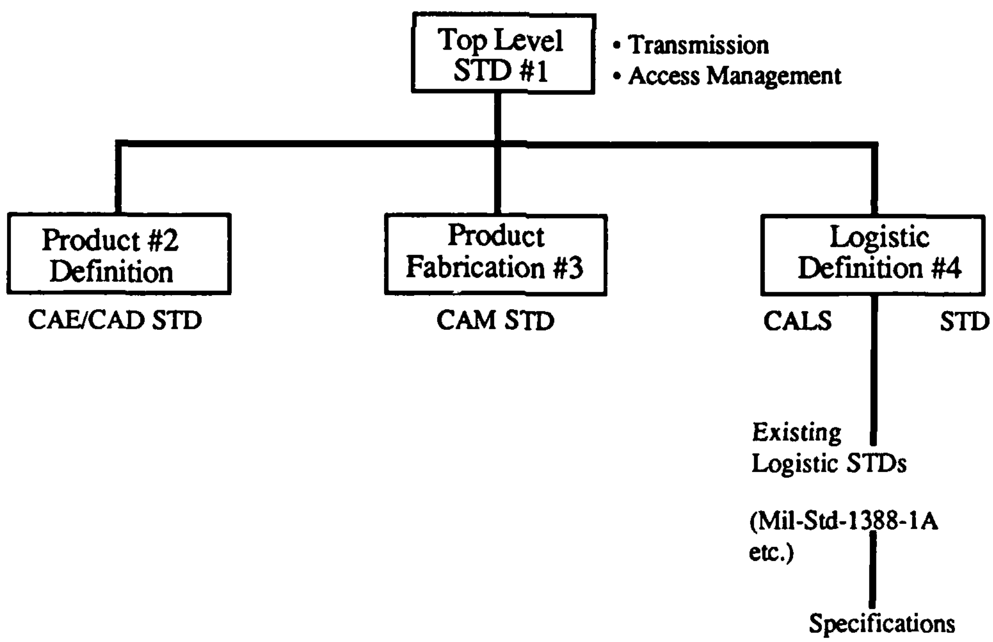


Figure 2. GENERAL RELATIONSHIP OF DATA BASE STANDARDS TO THE TOP LEVEL STANDARD

d. CALS DoD MIL-Standard

(1) General Discussion. Developing a comprehensive set of standard data element definitions for commonly used logistics parameters is a major challenge. Many programs exist or are under development today for automating technical information. An output of CALS is the integration of these programs to enhance computer-aided operations. In order to implement efficiently this multi-weapon system, multi-Service concept, standards are needed to define common data elements and data requirements in each ILS discipline.

Logistics Support Analysis (LSA) and the Logistics Support Analysis Record (LSAR) provide a model for the development of a CALS standard defining data elements and data requirements. MIL-STD-1388-1A identifies the LSA tasks to be accomplished during weapon system acquisition. LSA documentation records the results of those tasks. Data produced as a part of that LSA documentation are delivered by the performing activity in accordance with data element definitions, data item descriptions, and reports contained in MIL-STD-1388-2A, which describes LSAR requirements. Neither standard specifies how the performing activity should accomplish the LSA tasks, or which LSAR data the requiring activity should specify to meet weapon support needs.

MIL-STD-1388-2A also has taken the first (albeit incomplete) step in creating a central data element dictionary supporting the data requirements of the acquisition logistics and engineering (reliability and maintainability) communities. It not only supports logistics support analysis, but also the technical data requirements of the provisioning community. To achieve the objectives of a CALS standard applicable to all ILS disciplines, data elements for other logistic support disciplines must be added, i.e., training, technical publications, etc. In order to accomplish this task, functional specialty groups in the DoD acquisition arena must participate and cooperate in the development of a single CALS standard. Task and functional requirements of those individual specialty groups should continue to be identified by task-oriented standards such as MIL-STD-1388-1A. Data element definitions, data item descriptions and electronic report format options should be consolidated into a single CALS standard.

A DoD directive (similar to DoDD 5000.39, perhaps) or policy statement should require the establishment of a CALS standard that would act as an index and dictionary for the data required during logistics development and acquisition phases, including post-production. An evolutionary approach to development of this CALS standard, beginning with the foundation laid by MIL-STD-1388-2A, will facilitate progressive application to

ongoing (existing) programs and permit early application to new weapon system acquisitions.

(2) Approach to CALS Standard Development. The approach to the development of a CALS standard must recognize six basic criteria:

(1) Existing logistics tasks identified in present logistic MIL-STDs (i.e., MIL-STD-1388-1A, etc.) and specifications are to be retained.

(2) Existing logistics data requirements and DIDs will be reviewed to eliminate present data element duplication and inconsistency.

(3) The CALS standard will reduce and consolidate the number of present logistic DIDs.

(4) The CALS standard will reference the current logistics MIL-STDs which should be retained.

(5) The CALS standard would encourage tailoring for each program application.

(6) The CALS standard would be the primary contract instrument for identifying logistic information requirements.

e. Graphics Standard

DoD should consider specifying the Initial Graphics Exchange Specification (IGES) as the standard for delivery of engineering drawings and product definition data.

The Naval Sea System Command has issued two policy instructions that require the use of the IGES for this purpose. These policy instructions could be tailored by DoD to provide graphics standards for all military Services.

The first is NAVSEA Instruction 5230.8, "Transferring Technical Data Among Navy and Contractors' CAD/CAM Systems," dated 23 August 1984. This instruction requires that IGES Version 2.0 be used in exchanging product definition data among participating CAD/CAM systems except for work under the cognizance of the Deputy Commander for Nuclear Propulsion, NAVSEA 08. The instruction also requires that:

- IGES Version 2.0 will be invoked in all new contracts involving transfer of CAD/CAM technical data to and from NAVSEA.
- All offices, shore activities and detachments under the command of COMNAVSEA shall ensure that all solicitations, proposals and contracts for new construction, conversion modification, modernization and overhaul of naval ships, weapons development and engineering, design services and other new NAVSEA acquisitions incorporate IGES format whenever technical data are to be transferred between CAD/CAM systems. (Backfit of existing acquisitions programs is encouraged where cost effective and feasible.)

The second policy instruction is NAVSEA Instruction 9085.3, "Policy for Selected Record Drawings for Ship Acquisitions," dated 18 September 1984. This instruction requires that the shipbuilder deliver, with each ship, a master drawing for each ship. The master drawing shall be in two formats.

- Photo-Lithographic plastic, and
- Digitized Initial Graphics Exchange Specification-compatible format.

The Deputy Commander for Nuclear Propulsion (SEA 08) is also exempt from this requirement so long as the intent of the instruction is achieved.

f. Recommended Implementation Policy

(1) Development Plan. To begin the implementation process, DoD should issue a policy for fostering CALS. This policy must tie together ongoing and planned DoD logistics support efforts and create an integrated roadmap for CALS development, demonstration and phased implementation. In general, what appears to be needed are means to attack the following problems:

(a) A lack of an agreed-upon conceptual architecture encompassing a DoD-wide system.

(b) A lack of interfacing rules and/or standards that would allow rapid intercommunication between diverse systems.

(c) A lack of priority and funding for pilot/demonstration programs which would advance the overall strategy most effectively.

(2) Recommended CALS Schedule. (Refer to Figure 3.) CALS implementation should be a progressive process beginning with specified pilot programs. Pilot programs would demonstrate conceptual feasibility and could be used to examine and adjust, when necessary, the overall implementation strategy. This building block approach would permit systematic progress reviews and serve to identify system changes needed to assure reasonable success in subsequent implementation phases. Evaluation of pilot programs would identify required policy refinements and lead to a final DoD guidance to all Services.

g. Logistic Support Contract Analysis

Logistic support contract requirements imposed on four typical aerospace programs were analyzed to determine if changes to current contracting procedures were required to

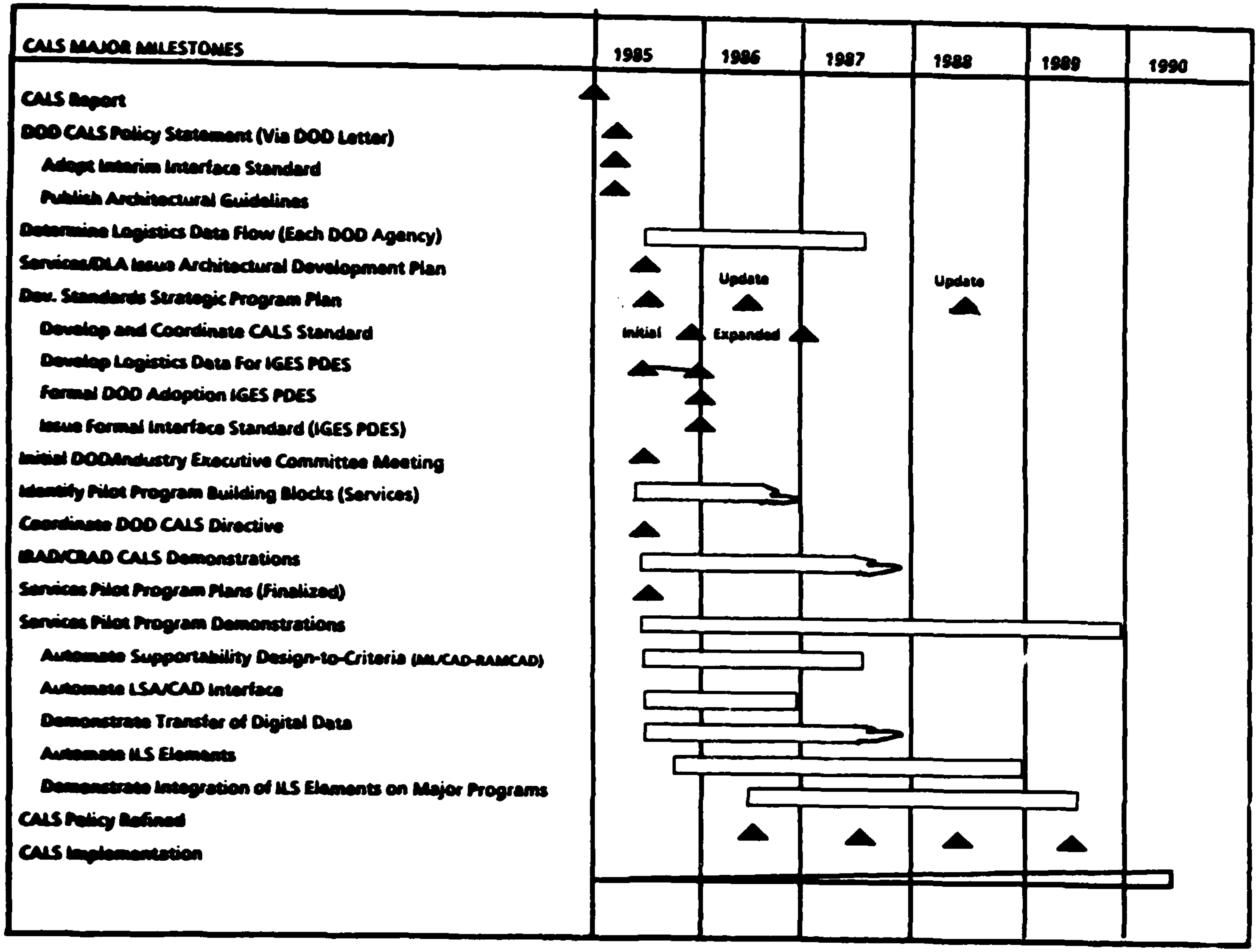


Figure 3. RECOMMENDED CALS SCHEDULE

implement a support program in a total electronic environment. The findings of the contract analysis are summarized as follows:

(1) The CDRL DD Form 1423 can be utilized to revise the delivery media from paper to electronic form.

(2) A technique must be established to define customer reviews, controllable audits, and acceptance for computerized data.

(3) Computer data control methods must be established to control working data, proposed data, approved data, and archival storage.

(4) No standard exists which defines electronic transmission media.

(5) The training/publications communities must revise current methods to develop and conduct support services.

C. LEGAL ISSUES

1. CALS Constraints--Public Law FAR

a. Legal Issues Concerning CALS

As we transition from an industrial society based on paper to an information society based on electronic information, we will use the computer more and more to manipulate, manage, and store our information needs in the forms of text, graphics, images and pictures. The requirements for the information may not change, but the format and media will change. Therefore, implementation of CALS will deal with software data rights and electronic data bases. A review of possible legal issues concerning CALS was made through the Federal Legal Information Through Electronics (FLITE) system, a computer-assisted legal research system for Federal users. The review did not highlight any legal constraints to inhibit CALS.

b. Area of Concern

Public Law 96-511, "The Paperwork Reduction Act of 1980," supports the transition from paper information to electronic information. One of the purposes of the law is:

> To ensure that automatic data processing and telecommunications technologies are acquired and used by the Federal Government in a manner which improves Service delivery and program management, increases productivity, reduces waste and fraud, and, wherever practicable and appropriate, reduces the information processing burden for the Federal Government and for persons who provide information to the Federal Government.

However, some provisions of Public Law 96-511 are not supportive of this goal when literally interpreted and applied. The law states that the Director, OMB, is responsible for:

(1) Reviewing and approving information collection requests proposed by agencies;

(2) Determining whether the collection of information by an agency is necessary for the proper performance of the functions of the agency, including whether the information will have practical utility for the agency;

(3) Ensuring that all information collection requests:

(a) are inventoried, display a control number and, when appropriate, an expiration date;

(b) indicate the request is in accordance with the clearance requirements of section 3507; and

(c) contain a statement to inform the person receiving the request why the information is being collected, how it is to be used, and whether responses to the request are voluntary, required to obtain a benefit, or mandatory;

(d) are disapproved where the Director determines that the agency has substantially modified in the final rule the collection of information requirements contained in the proposed rule where the agency has not given the Director the information required in paragraph (1), with respect to the modified collection of information requirement, at least 60 days before the issuance of the final rule.

A legal opinion is required to determine what impact Public Law 96-511 would have on CALS implementation.

c. Supportive Policy Issuances

(1) Executive 12352. Executive Order No. 12352, "Federal Procurement Reforms," supports the CALS objectives:

> To make procurement more effective in support of mission accomplishment, the heads of executive agencies engaged from the private section shall:....Establish programs....minimize paperwork burdens imposed on the private section.

(2) Federal Acquisition Regulation. The Federal Acquisition Regulation (FAR) represents the Federal Agencies' implementation of public laws. One particular section of the FAR which supports CALS is part 70 of the DoD FAR Supplement on the acquisition of computer resources. Part 70.4 of the DoD FAR Supplement covers the acquisition of Computer Resources under 10 USC 2315 Authority. This allows the procurement of computer resources directly without General Services Administration

(GSA) approval. This subpart is applicable to acquisition of automatic data processing equipment or services if the function, operation, or use involves, as its primary purpose, one of the following, which includes:

> Logistics systems which provide direct support to operating forces or provide support to maintenance of weapons systems (e.g., organic supply, software support facilities for weapon systems, etc.). This does not include logistic systems supporting contracting, accounting, disbursement and budgeting, etc.

Determinations as to the applicability of this subpart shall be made in accordance with DoD component procedures.

(3) DoD Directive 4245.7, Transition From Development to Production. This directive, dated January 19, 1984, authorizes the development of a manual to assist acquisition managers in the execution of technically sound system development programs. Guidance is provided by identification, assessment and reduction of program risk. CAD, CAM, software design and verification are program areas treated in the manual.

(4) The Defense Procurement Reform Act of 1984. This act requires the Secretary of Defense to develop a plan for an improved system for the management of technical data and a plan to improve the Services' computer capabilities to store and access rapid data that are needed for the efficient procurement of supplies.

2. CALS Data/Software Ownership

The issue of software rights is not presently covered by the FAR. Presently, the void is filled by each administrative agency issuing its own clauses and regulations. DoD has covered this in Part 27 of the DoD FAR Supplement and its implementing clause 52.227-7013, "Rights in Technical Data and Computer Software" [formerly DAR 7-104.9(a)]. These regulations set out the rights which the government may take in software within these two boundaries:

(1) As to software required to be originated or developed under a government contract, the government takes "unlimited rights."

(2) As to software developed with private monies or commercial computer software, the government takes "restricted rights" significantly restricting its use.

The DAR/DoD FAR Supplement scheme intends to balance out proprietary rights and the needs of the government, and has been relatively successful in doing so.

However, there is a trend to attempt to erode those rights by current legislation and pressures from government procurement personnel. Substantive issues include:

(1) Contractor Proprietary Rights to Software Developed Under IRAD Funds. While the government does contribute to IRAD, the entire scheme was developed to encourage private investment by permitting the contractor to retain proprietary rights (similar to the patent rights retention scheme). However, the argument is still being faced by contractors from those in government wanting to procure such proprietary items who claim that they should take ownership to those rights. Some agencies have proffered the argument that they should take such rights in view of their portion of overhead paid on items to which development may be charged.

(2) Government Monitoring of Rights. There is some question in the minds of contractors as to the ability of the government to monitor and track proprietary software in which it has acquired some rights to use for limited purposes. Additionally, the DAR and DoD FAR Supplement encourages the government to acquire only those rights and that software necessary. However, contractors have recently been faced with more requests for acquisition of rights in software without a predetermination having been made by the government buyers as to what is needed. This has even occurred on R&D efforts in which it is not even known at contact inception what types of software may be required.

(3) Confusion About Rights Acquisition. There has been substantial confusion as to rights obtained in software. While software documentation delivered under a CDRL becomes the government's in one sense, even if the software is provided with unlimited rights, the contractor retains intellectual property rights therein, including, but not limited to, the right to license usage by others. However, contractors are finding themselves in disputes as to "ownership" granted by the various levels of rights, and, consequently, wasting time and resources protecting the residual rights.

3. Proprietary Data Rights in CALS

In general, proprietary data do not migrate from the product definition data base in CAD/CAM to the ILS file. The prime contractor/suppliers do not incorporate proprietary data in technical manuals.

Proprietary data are used to develop spare parts and GSE provisioning data; however, the resultant provisioning data merely identify part numbers and general descriptions of the parts -- not how to manufacture the part.

Proprietary data will not reside in the ILS files -- they will be in the CAD/CAM file. The real issue then becomes a data rights issue of the product definition in CAD/CAM.

Congress is attempting to legislate certain limitations including limits on the time duration for proprietary rights and suggesting third party review of the propriety of the rights.

While the proprietary data rights issue is identified in our CALS report, it should be clearly stated that it is not a CALS issue. Proprietary data rights is a CAD/CAM issue, especially when we visualize government access to contractors' CAD/CAM file. The broader issue -- which CALS does recognize as a significant technical concern -- is CALS data access control. This issue encompasses proprietary vs non-proprietary data, classified vs unclassified data, and read/write vs read-only permission. Beyond the technical aspects of this issue, CALS policy must recognize that there will be limitations on data access for a variety of legitimate reasons, and that these limitations must be an explicit design consideration in any CALS system or data base.

D. INDUSTRY/GOVERNMENT IMPACT

1. Changes in Acquisition Process

The potential benefits of CALS implementation will be realized only if industry and government both accept the attendant changes in concept and methods of operation, which the paperless weapon system and paperless logistics system will necessitate. The structure of the weapon system acquisition process will change in many ways, among the most fundamental being:

Logistics influence on design,
Acquisition of logistics support data,
Competitive acquisition,
Data audit/approval techniques, and
Data and file transfer.

a. Logistics Influence on Design

The Logistic Support Analysis (LSA) process begins with "design to" supportability requirements levied on the designer. This must now be done through the CAD system so that the designer can incorporate the required supportability features during

the design process. Specific supportability design rules and algorithms must be included in CAD.

b. Acquisition of Logistics Support Data

Once the maintenance plan is approved, each Government Item Manager (spares, support equipment, technical publications, training equipment, etc.) must have access to the defined logistics support resources resident in CALS. With appropriate prior approval, use of these data could expedite preparation and justification of purchase requests. Additionally, government procurement agencies and competition advocates could use the CALS data to validate the purchase order and reduce procurement processing time. Methods for using computer data to expedite approval of purchase orders must be established by the government. Where possible, government procurement agencies should have the capability to place electronically transmitted contracts with the true manufacturer. Methods for receiving and processing electronically transmitted government orders for logistics support must be established by industry.

c. Competitive Acquisitions

In the CALS environment, reprocurement data packages as they are known today will be nonexistent. The data will reside in the product definition data file. Government access can be immediate to help increase competition for logistic support resources. This can eliminate or reduce government's cost of acquiring and maintaining reprocurement data packages. The reprocurement data file will also simplify government transition from CFE to GFE during the production cycle after system maturity and design stability are attained.

d. Data Audit/Approval Techniques

As paperless logistics support becomes available, improved data auditing and approval techniques must be developed. Data auditing in this context refers to assuring that integrated logistics support is in concert with the approved maintenance plan. This auditing could be done with appropriate edit and compare programs. The approval techniques refer to the requirement for government approval of the maintenance plan upon which the support system is built. The historical process of delivering multiple copies of literally thousands of pieces of paper for review and mark-up would be replaced by the CALS continuous flow of electronically transmitted data. New techniques for using remote

access/job entry terminals with on-line update capability must be developed to support these changes in methodology.

e. Data and File Transfer

At some point in time, the contractors'-developed CALS data will be transferred to a government agency(s). Issues to be addressed here are the method of transferring (i.e., on-line computer vs magnetic tape, etc.) and the degree of software standardization required. In the long term, the government needs to define their logistics data base requirements and integrate these with their existing automation system. In the near term, to capitalize on emerging technology DoD should recognize that the prime contractor's data will be transferred to the Logistic System Manager, so that he/she will not have to recreate a weapon system file. The inventory managers (IMs) can operate on-line with the unique weapon system file. When the government ILS Data Bank is defined, each contractor will format his data for direct transfer to the government as the product ends its production cycle.

Additionally, file-to-file transfers among government agencies would be extremely beneficial during Program Management Responsibility Transfer (PMRT). In the near term, the government would have to accept selected prime contractor data using common data access terminals. For the long term, the government must describe/develop CALS standards and provide for updating files as a result of post-production design changes.

2. Contractor Benefits

Contractors would benefit from CALS through improved logistics support capability and increased productivity. Logistics support would be improved by accurate proration recommendations for spares modifications. Status of repair of repairable components at vendor facilities would be available to prime contractors on a near-real-time basis. Also, CALS offers an opportunity for automated procedures for MILSTRIP requisitions and repair parts status reporting between Interim Contractor Support and government agencies.

Productivity gains would be significant. CALS data would be input, updated and maintained by the originator of logistics support information. Access by all users would eliminate the need for redundant files and significantly reduce the effort required for file maintenance. The potential for a common contractor/vendor data bank could create further productivity gains by reducing CDRL documentation requirements. Clearly, government

and industry productivity improvements resulting from CALS implementation would create engineering and logistics support efficiencies that would result in cost savings.

3. Government Benefits

CALs would provide the government's acquisition and logistics agencies with access to a common, single-source logistics data base. The Program Manager, System Manager (SM), Deputy Program Manager, Logistics (DPML), Resident Integrated Logistics Support Agencies (RILSA) and Item Managers would have engineering and logistics support data immediately available for acquisition, provisioning and procurement decisions. Resident Logistics Support Teams and Item Managers, including DLA, would share common data that could be used for rapid agreement on provisioning actions. The DPML and SM staffs would have information readily available to coordinate TCTO kit requirements for simultaneous modification of production and spare components. Current status of repairable components at Interim Contractor Support Facilities would permit expeditious amendments to shipping instruction when required.

CALS would permit logistics support considerations beginning with the conceptual phase and provide the government with early access to both design descriptions and logistics planning. Coupling information available in CAD with structured logistics support analyses gives an added dimension for producing a more supportable product. Improved quality and supportability would result in increased operational readiness and decreased life-cycle costs.

4. An Illustration of CALS Impact on Provisioning and Supply Activities

The application of current and evolving computer technology, combined with the availability of CAD and CAM data, will revolutionize the traditional logistics activities of provisioning and supply. DoD provisioning and supply activities include the functions of provisioning technical documentation (PTD) acquisition, spare/repair part procurement/reprocurement, inventory management, storage and distribution. Provisioning and supply activities have traditionally been expensive, unwieldy and not particularly responsive to the needs of weapon system users, managers or manufacturers. The primary obstacle to resolving these difficulties has been the impossibility of timely creation, processing, dissemination and update of the mountains of data that are associated with DoD provisioning and supply activities. With the advent of technologies that provide

inexpensive data storage, improved data communication, network-wide operating systems and distributed data bases, this no longer needs to be a constraining factor.

The application of existing and developing computer technology to DoD provisioning and supply activities will significantly alter the manner in which these are performed, improve their cost effectiveness, and make them more responsive to the needs of weapon system users, managers and manufacturers. Although the means of accomplishment will be altered, very little new data will be required. Rather, the same data that are currently required will be needed in a different format or on different media.

In the provisioning technical documentation arena, the application of these technologies will result in streamlining and standardizing the preparation/submittal/review/approval process. The remaining paper flow associated with PTD activities will be replaced with exchanges through digital media, and eventually through direct industry-to-DoD system communication. At the same time, the process that has been initiated with the development of MIL-STD-1388-2A will result in a standard industry-to-DoD provisioning data format for all DoD components. PTD efforts will increasingly be an integral part of the LSA/LSAR effort and will make extensive use of CAD/CAM parts list data. PTD screening activities will diminish in size and importance as data on parts presently in government inventory (Defense Logistics Supply Center data) are made more readily available to industry and are integrated with CAE and CAD parts selection and standardization systems. Traditional illustrated parts breakdown manuals (IPBs) and repair parts and special tools lists (RPSTLs) will be replaced with on-line computer data bases that provide DoD personnel with all necessary data concerning appropriate spare and repair parts.

The spare/repair parts procurement function will also undergo significant changes. The present manual and semi-automated spares delivery tracking systems will be replaced with on-line systems that are regularly updated with information from industry systems. These updates will initially be performed utilizing data that are transferred via removable computer media. Use of removable media for data transfer will eventually be phased out and replaced with direct communication between DoD and industry computer systems. The present difficulties encountered with acquisition and maintenance of reprocurement data will be surmounted through implementation of a variety of improved capabilities as a by-product of changes that are occurring in several other areas. Included among the improved capabilities are automation of DoD data repositories to allow improved retrieval of existing engineering data; procurement of new engineering data in computer sensible formats that are more accurate and easier to store, retrieve and update than are paper media; and

increased use of contractor data and personnel to facilitate identification of acceptable substitute and lower cost replacement items. Benefits will also accrue from changes that are occurring in the parts standardization area as a result of industry movement to the use of CAE and CAD systems. Increased use of standard and existing inventory parts will decrease the volume of data that must be acquired and maintained, while the movement to CAE and CAD systems will result in better designs that have fewer unique configurations and that require fewer retrofit and modification actions. The present "problem" of high cost spares and support equipment will disappear as weapon system designers make greater use of standard parts, DoD systems provide improved schedule and cost visibility to system managers, and incentives are put in place for industry to design systems that minimize the need for expensive and unique spare parts.

The task of inventory mangement will be greatly streamlined. On-line inventory management systems will provide improved visibility of inventory status, consumption rates and locations. These systems will allow DoD personnel to spot developing support problems and initiate resupply and procurement actions in a timely manner. Improved visibility of inventory location will allow system managers to make the best use of available assets and to eliminate the problem of inadvertent asset disposal. When coupled with improved feedback of field experience data, these systems will allow system managers to identify high payoff areas for modification and/or redesign. Weapon system users and supply activities will benefit from implementation of these systems by being able to quickly locate needed items and obtain current information concerning on-order items.

The storage and distribution function will also change as a result of the application of computer technology. Input from the inventory management systems and feedback from analysis of field experience data will allow identification of such storage and distribution problems as inadequate quantity allocations, excessive shipping times and excessive shipping costs. In the same way, inventory will be reduced through timely identification and disposal of unneeded items and more effective management of calibrated and limited life components.

ANNEX

List of Contributing White Papers

1. TITLE: CALS Concepts for Provisioning and Supply Activities
   DATE: 8/84
   SOURCE: McDonnell Aircraft Company
   AUTHOR: H. J. Correale (see Section D.4. above)

2. TITLE: Air Staff Initiative to Develop a Standard for Deliverable Data Base Systems
   DATE: 6/84
   SOURCE: Air Staff
   AUTHOR: N. Christiansen

3. TITLE: Standardization Overview
   DATE: 7/84
   SOURCE: Defense Materiel Standards and Specifications Office
   AUTHOR: B. Greene, B. Newlin, J. Dalgety

4. TITLE: Policy/Legal Constraints Subgroup Action Plan
   DATE: 6/84
   SOURCE: CALS Policy and Legal Subgroup
   AUTHOR: Subgroup Members

5. TITLE: Policy and Legal Constraints Subgroup
   DATE: 6/84
   SOURCE: CALS Policy and Legal Subgroup
   AUTHOR: Subgroup Members

6. TITLE: Institutionalized Contract Requirements
   DATA: 6/84
   SOURCE: Air Staff
   AUTHOR: N. Christiansen

7. TITLE: Thoughts on the First Meeting of CALS Group
   DATE: 6/84
   SOURCE: Department of the Navy
   AUTHOR: Emerson D. Cale

8. TITLE: Std to Acquire Tech Info in Digital Form and CALS Demo Action
   DATE: 9/84
   SOURCE: Chief of Naval Operations
   AUTHOR: E. D. Cale, S. C. Rainey

9. TITLE: CALS Data/Software Ownership and Proprietary Rights
   DATE: 10/84
   SOURCE: McDonnell Aircraft Company
   AUTHOR: H. J. Correale

10. TITLE: CALS What it is? What it is not?
DATE: 8/84
SOURCE: McDonnell Aircraft Company
AUTHOR: H. J. Correale

11. TITLE: CALS Contract Methodology
DATE: 10/84
SOURCE: McDonnell Aircraft Company
AUTHOR: H. J. Correale

12. TITLE: Computer-Aided Logistics Support Industry and Government Impact "A Paperless Airplane"
DATE: 10/84
SOURCE: McDonnell Aircraft Company
AUTHOR: H. J. Correale

13. TITLE: Recommendations for Implementing Action on Graphics and Text Standards
DATE: 6/85
SOURCE: IDA
AUTHOR: B. Lepisto

14. TITLE: Logistic Support Contract Analysis
DATE: 9/84
SOURCE: McDonnell Aircraft Company
AUTHOR: H. J. Correale (published in Volume III, Report of Information Requirements Subgroup)

CALS CONCEPTS FOR PROVISIONING AND SUPPLY ACTIVITIES

(see Section D.4 above)

H. J. Correale

McDonnell Aircraft Company

AIR STAFF INITIATIVE TO DEVELOP A STANDARD FOR DELIVERABLE DATA BASE SYSTEMS

N. CHRISTIANSEN

Air Staff

June 24, 1984

AIR STAFF INITIATIVE TO DEVELOP A STANDARD FOR A DELIVERABLE DATA BASE SYSTEM

Our interest in this subject continues to grow as realizations of paperless systems evolve. At Air Staff our responsibilities center on the integration of management policy specifically for acquisition, program management direction, systems engineering, and embedded computers. Most recently we have been tasked with logistics R&D, acquisition logistics and the departmental standardization office. Our place is full and varied, but this is not totally detrimental. Like most Air Force offices we could do more with more people, but then we would lack cross fertilization that allows our small staff to gain insight into developing trends and new ideas. One of these new ideas is the proposed standard for a deliverable data base system. The idea is one way to assure that the Air Force receives adequate engineering data to allow the competitive procurement of spare parts, which brings us to the origin of the idea:

The 1983 AFMAG investigating the competitive procurement of spare parts was keenly interested in the causes for our inability to buy spare parts competitively. To expedite the investigation of these causes, the AFMAG was divided into two groups: a requirements group and an execution group. These groups were subdivided into panels: the data management panel concentrated on the question, "why don't we have the data in hand to complete the acquisition of spare parts?" Their investigation examined the procedures used for buying engineering drawings and associated lists to stock an Air Force assembled data base, the contractor's method of drawing preparation, and the Air Force's way of reviewing and accepting contractor prepared data. They found the procedures contained many stumbling blocks.

- DoD directives require the acquisition of drawings and associated lists as data.

- Contractor prepared drawings are not subjected to an actual demonstration for future uses.
- General lack of logistics considerations.
- Provisioning is done too early; in too short a time.
- Drawing storage and transmission techniques are outmoded.

DoD directives force the Services to buy engineering drawings and associated lists in the same manner as short term management data. They require the Services to tailor specifications, standards and data item descriptions to match the current acquisition, paying little regard to future needs. This practice is perpetuated by the Data Requirements Review Board that scrubs data requirements to reduce the amount of data procured--a temporary expedient that can often eliminate data needed for breakout/competition. Contractor-prepared drawings are never subjected to an audit that would vigorously demonstrate their capability to support breakout, competitive acquisition or to justify proprietary rights claims. The physical configuration audit is our last look at drawings before delivery. This audit checks to see that the drawings depict the item produced, not that the drawings can be used to produce the item.

Post production support or interim contractor support may be planned for early on in the acquisition process, but the specifications, standards and data item descriptions used to buy drawings are not conducive to producing a data system to support post production support by a contractor other than the prime. Interim contractor support is usually applied as a catch-up sole source contract. Provisioning exercises are forced and occur too early under unfavorable circumstances -- normally with insufficient or incomplete drawings. Acquisition (procurement) method coding is often performed by personnel who have little knowledge about the items being coded and usually under exceedingly short time constraints. Drawings are required to be delivered to outmoded standards, microfilm on aperature cards.

Microfilm technology requires strigent drawing room practices that are no longer in use by major contractors. Microfilm is subject to physical damage and loss (the latest Air Force audit reported that 10% of those cards removed from files never find their way back, and 20% of the cards have illegible content). Repository equipment is outdated and AFLC has been informed by the servicing contractor that he will no longer service some equipment. A number of good initiatives are in work now to correct these stumbling blocks.

Present DoD policies and procedures tend to:

- Freeze copies of the evolving drawings, cut the copies off from the parent data base, and use the documents in isolation.
- Encourage the buying of insufficient and obsolete drawings.
- Force the services to contrive a permanent data base piecemeal.
- Prevent services from achieving self sufficiency.
- Have the contractor prepare drawings to match his internal needs without considering the future needs of the Air Force.

Data management panel discussions on how to overcome these stumbling blocks led to the realization that for years we have been trying to assemble effective Air Force data base systems for weapon systems, without success. In short, the panel concluded that the piecemeal assembly of a multi-purpose data base from a weapon system, subsystem or equipment acquisition was impossible under present data acquisition policies. Yet we desperately need to have these data bases. Service-owned data bases are essential for the life cycle support of fielded systems or equipment. They provide the Service some element of independence from their prime and vendor contractors. They also allow the making of

independent decisions. But for all our special management interest shown in the past, we remain dependent on the contractor's data base to provide the support needed.

So the Panel's question eventually came down to "why don't we tell the contractor what we want a data base to do, then turn to him loose and let him develop the data base system." The panel reasoned that the Air Force needs to stop thinking of engineering drawings and associated lists in terms of paper products and open the door to the Services' conversion to automated technical information systems. Instead of adding patches to our already old and leaky data handling system, we should write a new comprehensive standard for a deliverable Air Force data base system. Then, place the requirement for the development of a data base system in the contract as a line item deliverable just as we do for the system, equipment or software.

The new standard would require the contractor to develop or assemble a data base that does all the functions that the contractor's data base normally does, as well as those functions that enhance future management of the program. He would be required to consider upfront in design the issues of breakout, provisioning, acquisition data package identification, acquisition method coding, and competitive acquisition of spare parts. The standard would contain requirements to develop and build a functioning data system that could be demonstrated, tested and audited. Thus we would be assured of sufficient technical data to manage the system/item throughout its life cycle.

Buying an Air Force data base system as a contract line item has several benefits:

- Unify commands requirements.
- Provide in management alternatives.
- Allow phased modernization of techniques.
- Program management responsibility transfer asset.

An Air Force data base system would have other benefits: It could serve as a precontract agreement between the implementing and the supporting commands; become that single tailored standard to show a united Air Force to the contractor; place it on contract as a line item, removing it from the normal data requirements review process; and it would no longer be subjected to data requirements review board scrub or program cuts.

Also, having a deliverable data base system would place the Air Force in a very flexible position. We could choose to contract with the prime to maintain the system of a post-production support-type contract and deliver hard copy to selected Air Force offices as needed; contract with the prime to set up and maintain satellite data terminals at air logistics centers, operational units, or other locations; take delivery of the system and integrate it into the depot's system, or, depending on the size or application, take delivery of the system and turn it over to an operational unit or other custodian for management and upkeep.

Yet another advantage to having the contractor develop and build a deliverable data base is that the contractor can be encouraged to use the most modern techniques for data storage and transmission. In his article, Senior Executives After Reform 88, Mr. Reynolds observed that PL 96-511 may be called "The Paperwork Reduction Act of 1980," but it deals mostly with paper's replacement -- computers. Our data repositories are geared to paper copy type storage and retrieval. Edcars will certainly help automate the old paper techniques, but we need to phase in modern computer aided information systems. We think the standard will make this happen. Finally, a deliverable data base system would also provide a tangible asset to transfer from the implementing command to the supporting command at the time of program management responsibility transfer. Transfer of ownership of the data system would truly represent a total shift

in responsibility, because the supporting command would take possession, at least contractually, of the data base that controls the configuration of the weapon system.

The data management panel toyed with this idea for several weeks and considered it worthy enough to prepare a draft standard. Their standard includes those functions that the data base must perform. It is a rough draft that was assembled by taking excerpts from the various standards that cover the system's acquisition life cycle. It simply shifts some of the responsibilities of the government to the contractor. Now he must develop a data base system, and we can inspect, test, audit and, yes, even reward his efforts based on the requirements set forth in the standard. Unfortunately, the AFMAG, while still supportive of the idea, realized that it could take time to nurture and sell the idea to the established data management community and offices that govern the acquisition of data. Also, before the panel could proceed with a radical departure from the established information management system they would have to obtain permission from the Office of the Secretary of Defense. Since the AFMAG did not have sufficient time to generate the support for the standard or pursue its approval, they chose to work within the existing data management system and to recommend improvements to areas that would enhance the assembly of a viable data base. These recommendations are now being integrated into the various regulations, specifications and standards that are used to acquire data. Air staff believes the idea has potential, especially as an instrument to break away from a paper product world and convert to automated technical information systems. Therefore we have picked up the idea and are actively soliciting support for the idea.

STANDARDIZATION OVERVIEW

B. Greene, B, Newlin, J. Dalgety

Defense Materiel Standards and Specifications Office

June 1984

STANDARDIZATION OVERVIEW

DEFENSE MATERIEL SPECIFICATIONS AND STANDARDS OFFICE

MR. KURT GREENE

MR. BURT NEWLIN

MR. JIM DALGETY

5203 LEESBURG PIKE

SUITE 1403

FALLS CHURCH, VIRGINIA 22041-3466

TELEPHONE: (703) 756-2345

ROLE OF STANDARDS

SPECIFICATION:

- A DOCUMENT PREPARED SPECIFICALLY TO SUPPORT ACQUISITION

STANDARD:

- A DOCUMENT THAT ESTABLISHES ENGINEERING AND TECHNICAL REQUIREMENTS FOR SELECTION, APPLICATION AND DESIGN CRITERIA FOR MATERIEL.

ADVANTAGES:

- MAJORITY OF STANDARDS ARE VOLUNTARY.
- THEY IMPROVE OPPORTUNITIES FOR TECHNICAL PROGRESS.
- THEY INCREASE ORDER/REDUCE PROLIFERATION.
- LOWER LIFE-CYCLE COSTS.

MISCONCEPTIONS:

- TEND TO REDUCE COMPETITION.
- TEND TO RESTRICT USING LATEST TECHNOLOGIES.
- ARE OFTEN TOO RESTRICTIVE.

SPECIFICATIONS, STANDARDS, AND RELATED DOCUMENTS

DOCUMENTS THAT ESTABLISH AND DEFINE REQUIREMENTS FOR PURCHASED MATERIEL, PROCESSES, PROCEDURES, PRACTICES, METHODS, AND DATA. SUCH DOCUMENTS ENCOMPASS ALL MILITARY, FEDERAL, AND NONGOVERNMENT SPECIFICATIONS AND STANDARDS, DATA ITEM DESCRIPTIONS (DD FORM 1664), AND OTHER DoD ISSUANCES THAT HAVE THE SAME EFFECT AS SPECIFICATIONS AND STANDARDS WHEN CITED IN SOLICITATIONS AND CONTRACTS

PRODUCT
DOCUMENT (SPECIFICATION)

A DOCUMENT, THAT ESTABLISHES AND DEFINES THE ESSENTIAL REQUIREMENTS FOR SPECIFIC PURCHASED MATERIALS, PARTS, COMPONENTS, SUBASSEMBLIES, ASSEMBLIES, AND EQUIPMENT. THESE PRODUCTS ARE COVERED BY DOCUMENTS WITHIN THE DEFINED SCOPE OF THE FEDERAL SUPPLY CLASSES AND GROUPS.

1107-1

NONPRODUCT DOCUMENT (STANDARD)

A DOCUMENT, THAT ESTABLISHES AND DEFINES REQUIREMENTS FOR MANAGEMENT, DESIGN PROCESSES, PROCEDURES, PRACTICES, METHODS, AND DATA APPLICABLE TO A BROAD RANGE OF PRODUCTS

1107-1

STANDARDIZATION PUBLIC LAW

TITLE 10 UNITED STATES CODE CHAPTER 145, CATALOGING AND STANDARDIZATION, SEC. 2451-2455, CHARGES SECRETARY OF DEFENSE WITH DEVELOPING AND MAINTAINING A STANDARDIZATION PROGRAM TO:

- DEVELOP AND USE SINGLE SPECIFICATIONS
- ELIMINATE OVERLAPPING AND DUPLICATE SPECIFICATIONS
- REDUCE NUMBER OF ITEMS
- MAKE FINAL DECISIONS RE CATALOGING AND STANDARDIZATION
- REPORT TO CONGRESS ANNUALLY

1130-2

DEVELOPMENT OF STANDARDS

- **POLICY:** **EXAMPLES**

• OMB A-119	FEDERAL PARTICIPATION IN THE DEVELOPMENT AND USE OF VOLUNTARY STANDARDS
• DODI 4120.20	DEVELOPMENT AND USE OF NON-GOVERNMENT SPECIFICATIONS AND STANDARDS
• DODD 4120.3	DEFENSE STANDARDIZATION AND SPECIFICATION PROGRAM
• DODD 5000.11	DATA ELEMENTS AND DATA CODES STANDARDIZATION PROGRAM
• DODI 5010.12	MANAGEMENT OF TECHNICAL DATA

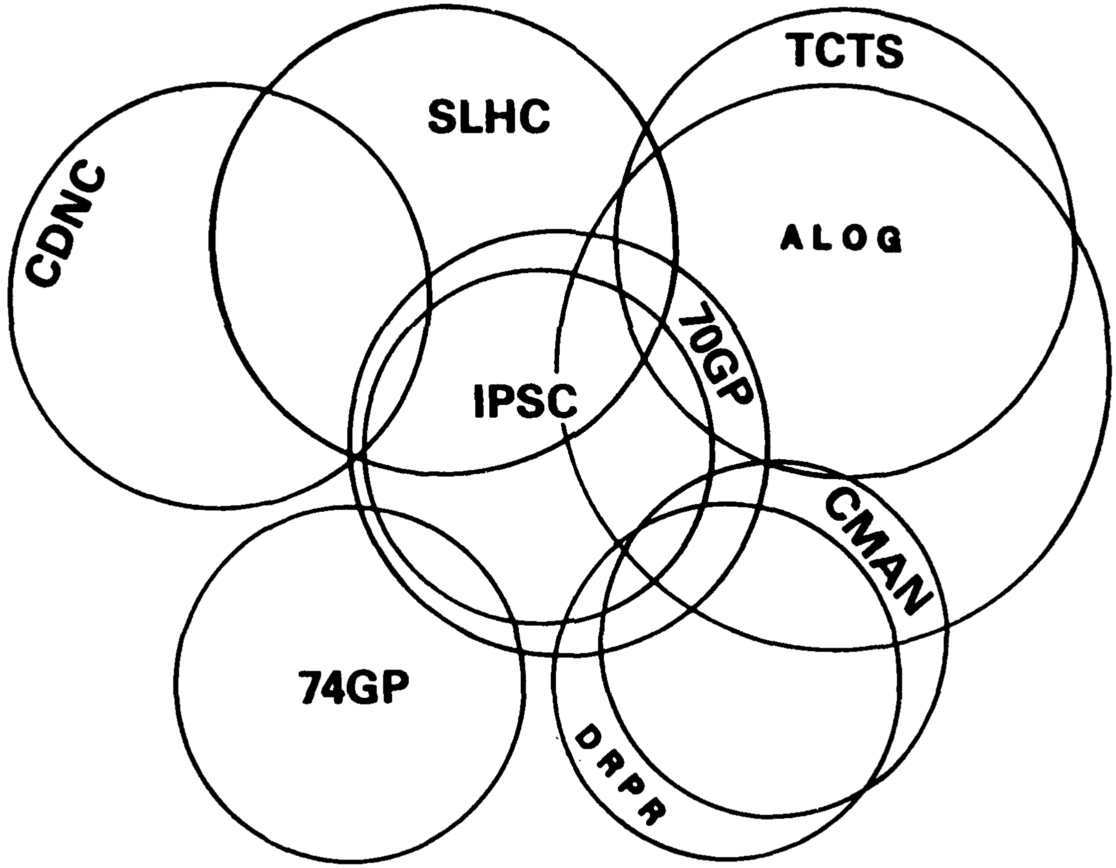
DEVELOPMENT OF STANDARDS

- **TYPES OF STANDARDS**
  - MILITARY STANDARDS (MIL-STD-1388 AN EXAMPLE)
    FULLY COORDINATED, LIMITED COORDINATED
  - FEDERAL STANDARDS
  - NON-GOVERNMENT STANDARDS ORGANIZATION
    ANSI, ASTM, IEEE, SAE, ETC.
  - INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
    (ISO)

DIRECTLY RELATED STANDARDIZATION AREAS TO STUDY

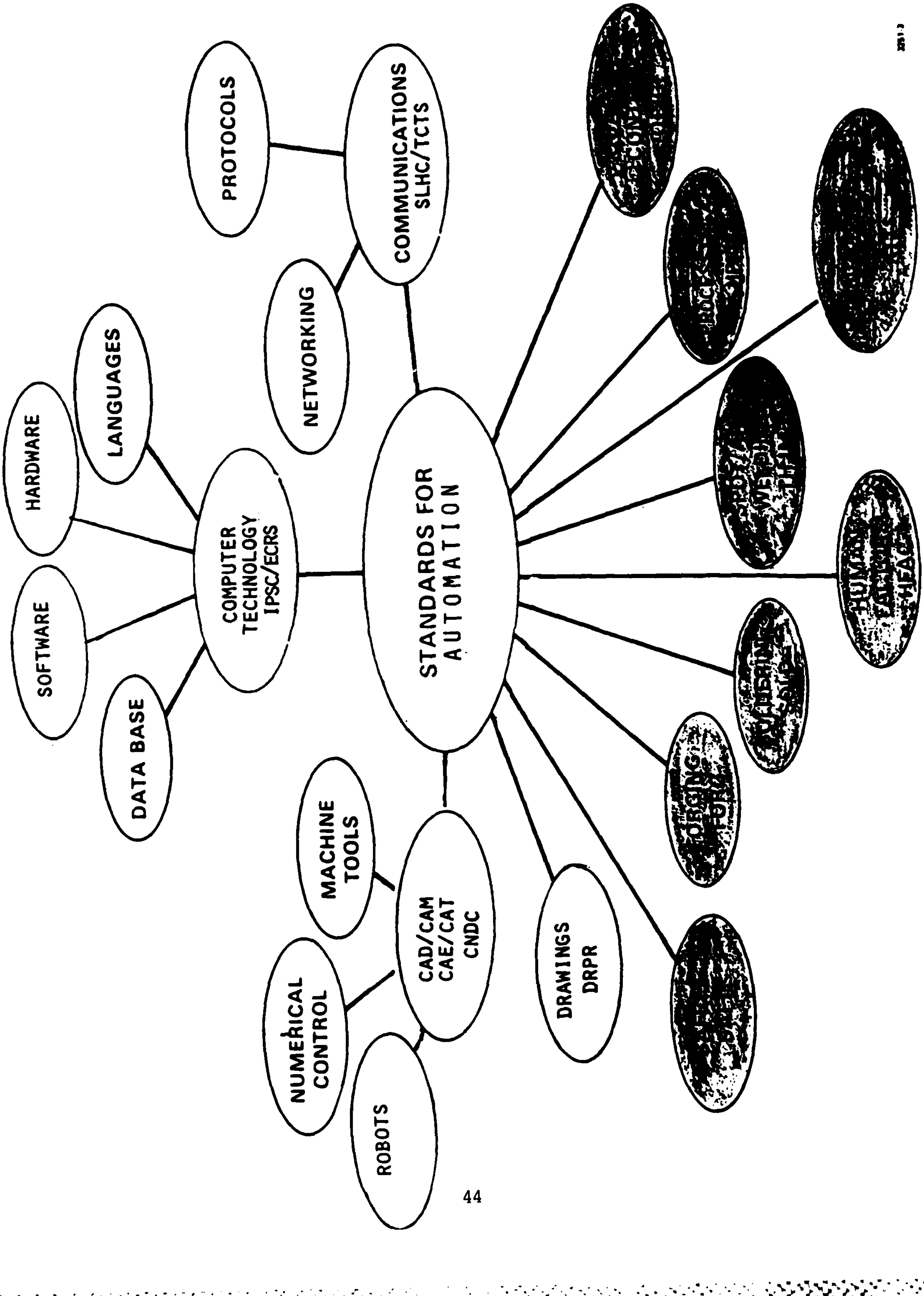
AREA	TITLE
ALOG	ACQUISITION LOGISTICS (NEW AREA BEING ESTABLISHED)
IPSC	INFORMATION PROCESSING STANDARDS FOR COMPUTERS
CDNC	COMPUTER AIDED DESIGN NUMERICAL CONTROL
SLHC	LONG-HAUL COMMUNICATIONS
TCTS	TACTICAL COMMUNICATIONS
CMAN	CONFIGURATION MANAGEMENT
DRPR	DRAWING PRACTICES
DCPS	DATA COMMUNICATIONS PROTOCOL STANDARDS

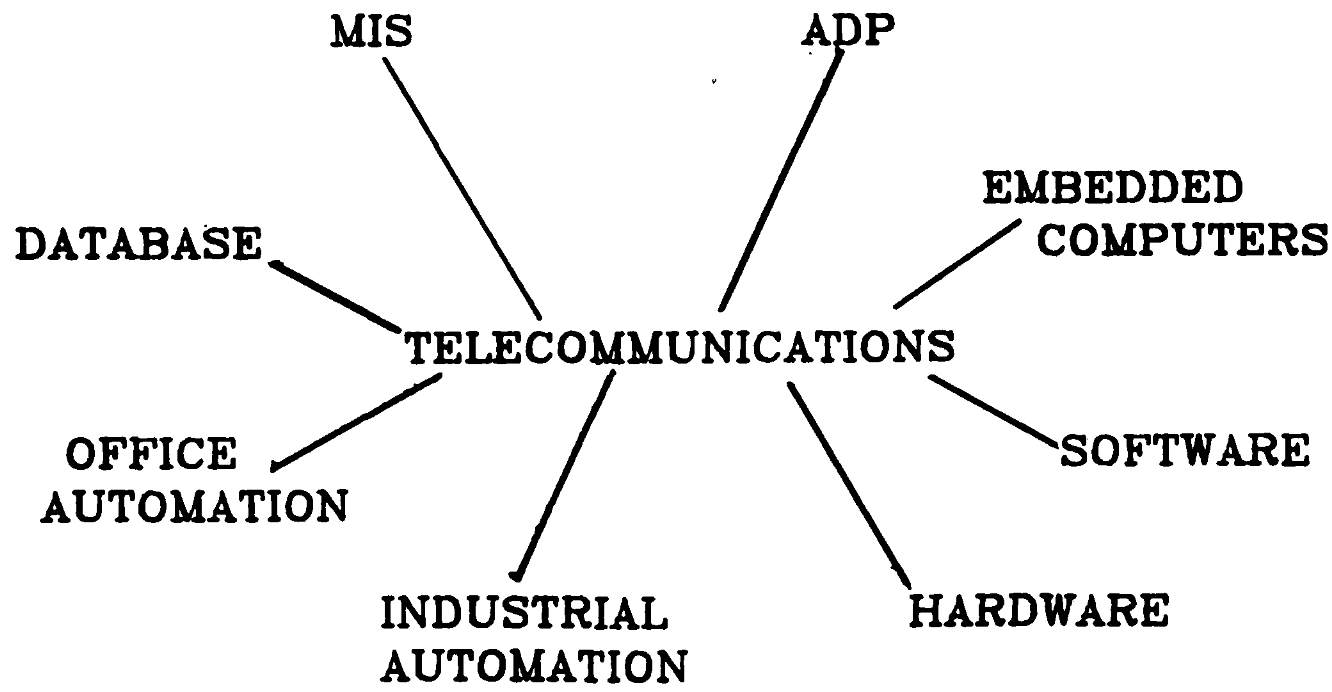
OVERLAPPING STANDARDIZATION RESPONSIBILITIES



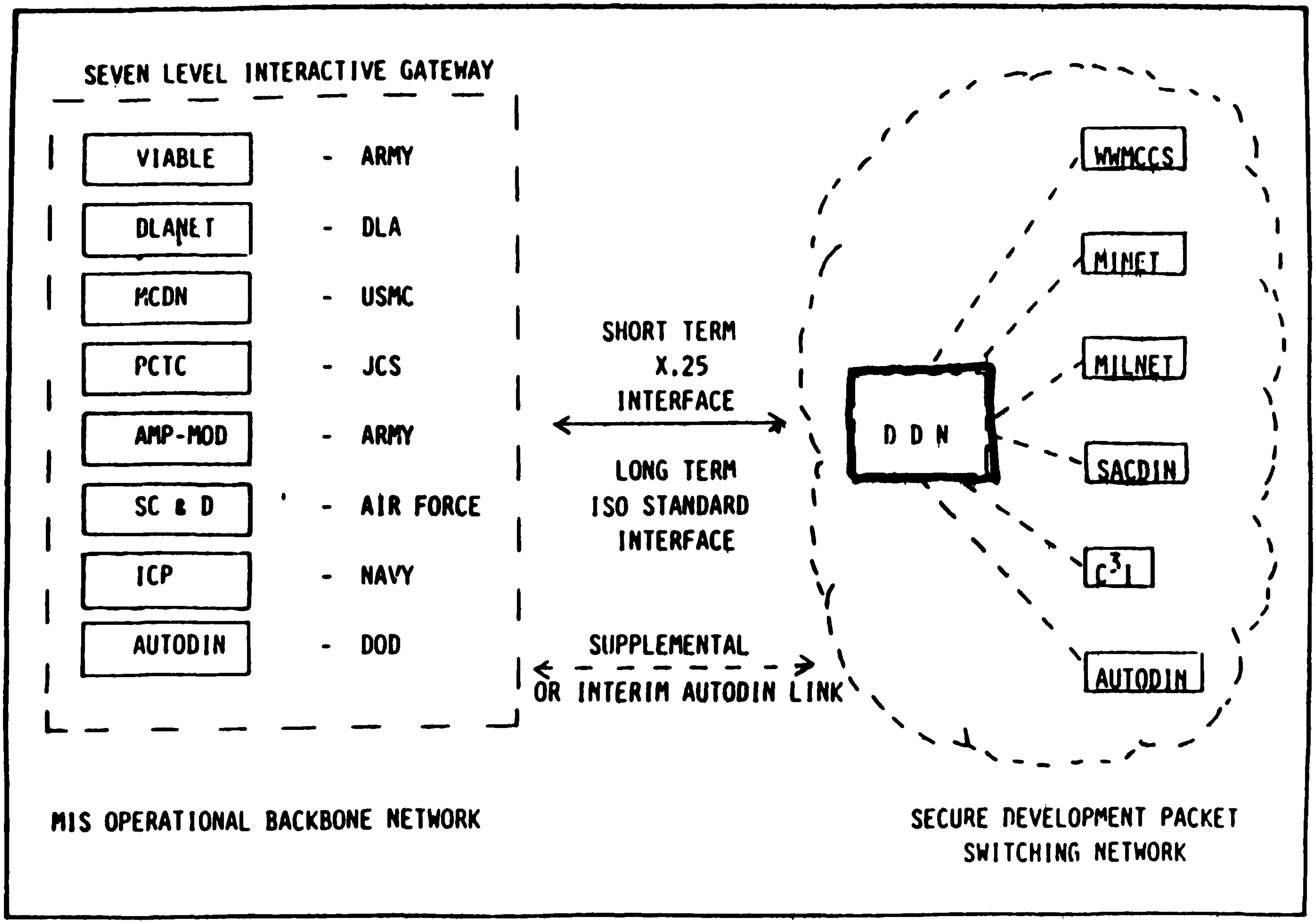
ASSOCIATED STANDARDIZATION AREAS

ATTS	AUTOMATIC TEST TECHNOLOGY STANDARDS
ECRS	EMBEDDED COMPUTER RESOURCES STANDARDS
FORG	FORGINGS
HFAC	HUMAN FACTORS
MECA	METAL CASTINGS
MFFP	METAL FINISHES AND FINISHING PROCESSES AND PROCEDURES
QCIC	QUALITY CONTROL/ASSURANCE AND INSPECTION
SAFT	SAFETY
SOLD	SOLDERING


STANDARDS FOR AUTOMATION
COMPUTER TECHNOLOGY IPSC/ECRS
HARDWARE
LANGUAGES
SOFTWARE
DATA BASE
COMMUNICATIONS SLHC/TCTS
PROTOCOLS
NETWORKING
CAD/CAM CAE/CAT CNDC
MACHINE TOOLS
NUMERICAL CONTROL
ROBOTS
DRAWINGS DRPR



INFORMATION TECHNOLOGY



Recommended Network Integration Approach GOVERNMENT EXECUTIVE JUNE 1984

DIGITAL INFORMATION EXCHANGE

TEXT AND GRAPHICS STANDARDS

GENCODE

IGES NAPLPS

GKS VDI

VDM

GENCODE - GCA STANDARD 101-1983, DOCUMENT MARKUP METALAUGUAGE. PROPOSED ISO AND ANSI X3J6 (TEXT & GRAPHICS WINDOW)

NAPLPS - NORTH AMERICAN PRESENTATION LEVEL PROTOCOL SYNTAX, ANSI X3.110-1983; CANADIAN CSAT-500-1983, CHARACTER CODED SCREEN PAINTING STANDARD FOR RASTER SYSTEMS (FOR DATA COMMUNICATIONS, VIDEOTEX/TELETEXT)

IGES - INITIAL GRAPHICS EXCHANGE SPECIFICATION, APPROVED ANSI Y14.26M, VERSION 2.0 UNDER REVIEW, GRAPHICS DATA BASE EXCHANGE STANDARD

GKS - GRAPHICAL KERNEL SYSTEM (GRAPHICS SOFTWARE - SUPPORT TWO-DIMENSIONAL PICTURES) PROPOSED ISO AND DRAFT ANSI X3H3/83-25R1, 2D STANDARD

VDM - VIRTUAL DEVICE METALFILE (GRAPHIC DATA EXCHANGE FILE FORMAT), PROPOSED DRAFT X3H3/83-15R1 STANDARD

VDI - VIRTUAL DEVICE INTERFACE (GRAPHIC DEVICE - INDEPENDENT INTERFACE), PROPOSED ANSI X3H3.3 STANDARD

DIGITAL INFORMATION EXCHANGE
TEXT AND GRAPHICS STANDARDS

DIF

CORE PHIGS

DIF - DOCUMENT INTERCHANGE FORMAT, NBSIR-84-2836, APRIL 84 (FOR TEXT PROCESSING SYSTEMS).

CORE - 3-D REPRESENTATIONAL STANDARD DEVELOPED BY THE SPECIAL INTEREST GROUP ON COMPUTER GRAPHICS (SIGGRAPH) OF THE ASSOCIATION FOR COMPUTING MACHINERY (ACM).

PHIGS - PROGRAMMER'S HIERARCHICAL INTERFACE TO GRAPHICS STANDARD, PROJECT ANSI X3H3.1

STANDARDIZATION SUMMARY

- NUMEROUS ONGOING ACTIVITIES
  - COMMUNITY CONCERN
  - STRUCTURE IN PLACE
- INTERFACE STANDARDS NEEDED
  - TECHNOLOGY TRANSPARENT
  - VENDOR INDEPENDENT

POLICY/LEGAL CONSTRAINTS SUBGROUP ACTION PLAN

Subgroup Members

CALS Policy and Legal Subgroup

June 12, 1984

POLICY/LEGAL CONSTRAINTS SUBGROUP ACTION PLAN

1. Scope and subgroups task and task assignments.

A. Legal Issues - Burt Newlin

o Examine Current Laws/Regulations/Constraints
o Examine Product Rights/Product Integrity/Product Liability

a. Burt Newlin will collect pertinent laws and regulations and categorize the constraints.

b. He will then task subgroup members to assist in analyzing specific regulations, laws, specifications and standards to develop recommended changes. Item I.A.a. will be completed by next meeting.

B. Policy Issues - All Members

o Research Requirements/Standards/Timing/Configuration Management/Gov't Audit/Transmission.

The whole group will address Policy Issues. The initial brainstorming session has identified potential issues which will be refined and sent to the CALS committee. Our objective is to guide other subgroups to assure that they address all of the policy issues in the context of their individual charters. Howard Chambers will handle integration of subgroup inputs.

C. Implementation Roadmap

o Examine DoD instructions/DAR-FAR/Contracting
o Evaluate Pilot Programs/Options/Conversion/Media by program phase/(take user-need approach)

a. Neil Christianson will lead this activity using the same approach outlined in I.A above.

2. Matrix Overview

It was agreed that a policy matrix will be prepared to scope the logistics support activities (both design-to and support) as they relate to the major policy areas. Howard Chambers will prepare this strawman matrix. This matrix will be available to policy subgroup members within one week. This matrix will help us focus on the real issues.

POLICY AND LEGAL CONSTRAINTS SUBGROUP

Subgroup Members

CALS Policy and Legal Subgroup

June 12, 1984

POLICY LEGAL CONSTRAINTS SUBGROUP

Notes on 12 July 84 Meeting

1. Scope and subgroups task and task assignments.

A. Legal Issues

o Current Laws/Regulations/Constraints
o Product Rights/Product Integrity/Productability

(Burt Newlin will collect pertinent laws and regulations and categorize the constraints.)

B. Policy Issues

o Requirements/Timing/Configuration Management/Gov't Audit

(The whole group will address Policy Issues - see below)

C. Implementation Roadmap

o DoD Instructions/DAR-FAR/Contracting
Pilot programs/options/conversion/(take user-need approach)

2. Matrix Overview

It was agreed that a matrix presentation that would scope the logistics support data proved to be useful. (Howard Chambers will provide his view of such a matrix.)

3. A group discussion of policy issues was held which resulted in the following unstructured list of candidate policies and questions:

(i) Policy to motivate contractors to develop support data as part of their CAD/CAE data base homework.

(ii) Policy to deal matrix digital data format/delivery defintion to replace paper world definitions in our current contractive procedures.

- requires that the government is able to receive digital data

- may restrict flexibility of current system

- may create problems with small contractors

(iii) Policy to deal neither the proliferation of many different types of computer hardware and software in use in DoD business in order to contain interfacimg problems.

(iv) Policy to have contractors develop digital data bases which would meet stated needs rather than specifying exact data packages for delivery.

- Software can now be bought; why not extend this to engineering data, maintenance data, etc.

- current system does not allow buying such data or even having contractor maintain it for DoD use.

- currently a spec or a standard is the only basis for specifying data delivery.

(v) Is there a policy for CAD/CAM which could be used as a model for CALS?

(vi) Must insure that any CALS policy does not constrain CAD/CAM architecture.

- want to be able to feed back lessons learned

- CALS data must be available from CAD/CAM data base but don't constrain early phases of design by CALS policy.

(vii) Policy regarding responsibility for CALs maintenance throughout the life cycle of the system.

(viii) Policy to define the scope and definition of CALS.

- is CALS an entity or is it an indistinguishable part of the process of digitizing the whole acquisition and support process.

- what is the content of CALS either separately or as part of the greater entity.

(ix) All CAD/CAM/CALS policies must pass the filter of technology transparency

-the intent of policicies for computer-aided systems is to utilize new technology not to impede future technology changes.

(x) Policy must be flexible enough to handle large and small contractors, included.

- above this level options should be available to handle intermediate levels of complexity

(xi) Policy must be established to handle the process of conversion to digital data and unified data bases.

- driving conversion both tapes and drawings may be required

- people msut be trained to use digital data

- conversion generally involves increased cost and reduced efficiency. It must be planned as to timing and cost.

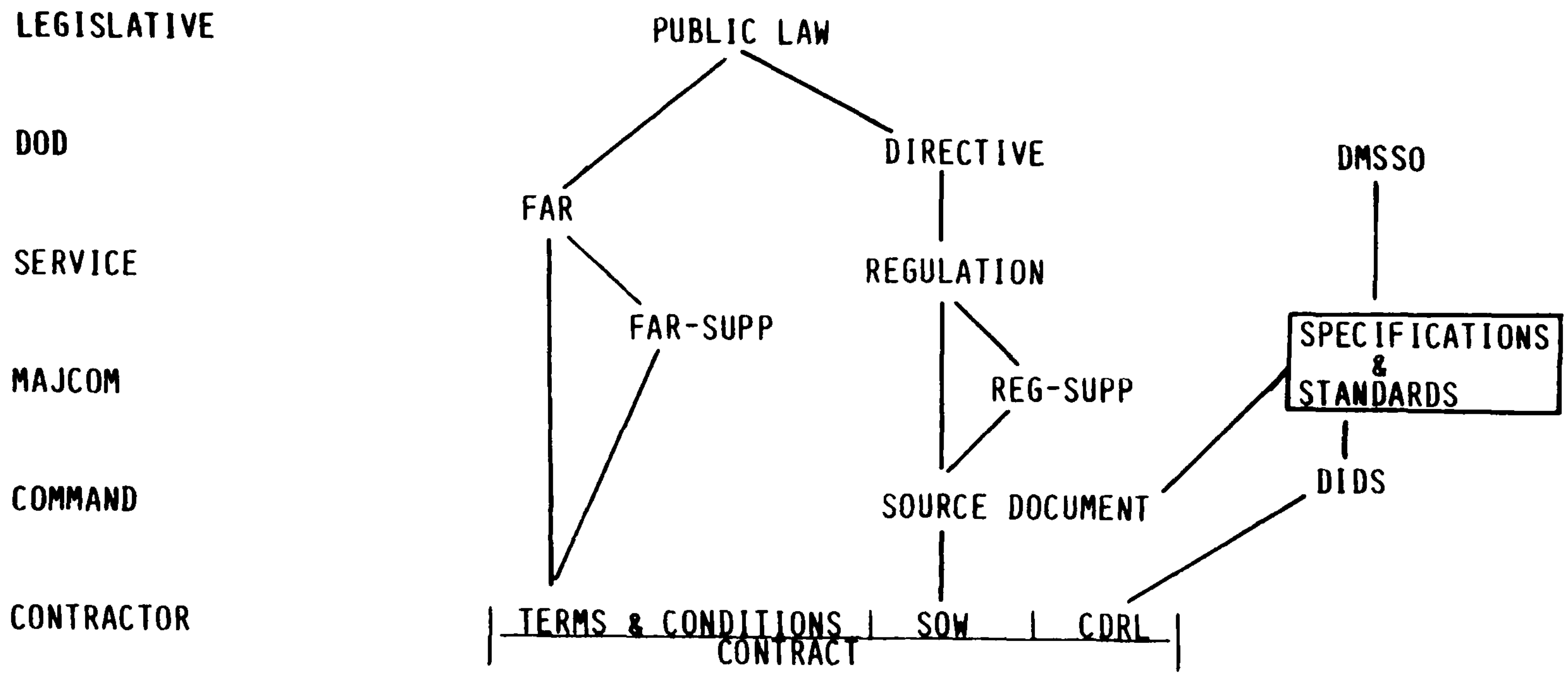
(xiii) Policy regarding access to digital data is needed rather than delivered data packages which are often overspecified.

INSTITUTIONALIZED CONTRACT REQUIREMENTS

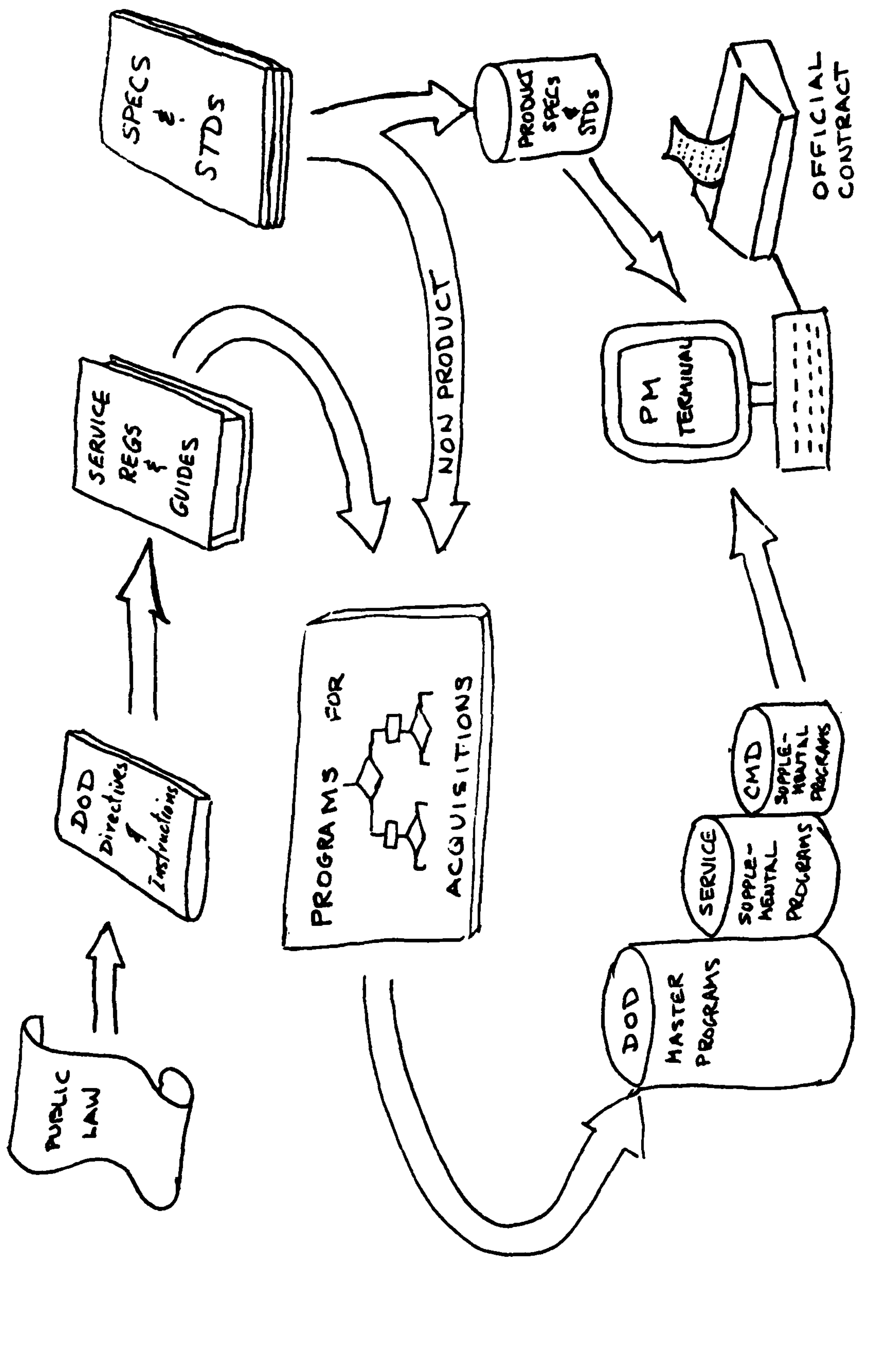
N. Christiansen

Air Staff

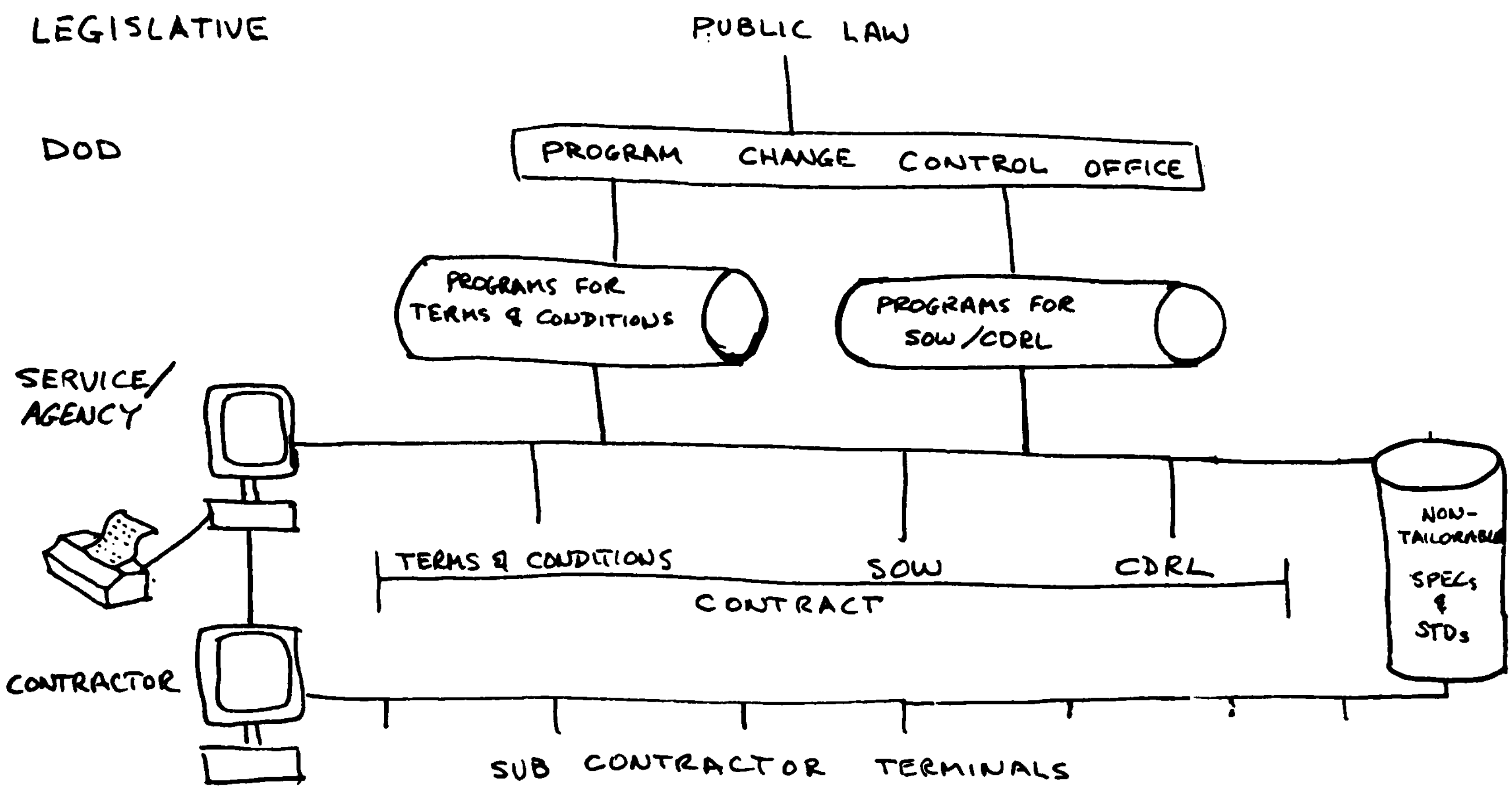
June 24, 1984



INSTUTIONALIZED CONTRACT REQUIREMENTS



CONSOLIDATED CONTRACT REQUIREMENTS



NEW INSTUTIONALIZED CONTRACT REQUIREMENTS

THOUGHTS ON THE FIRST MEETING OF CALS GROUP

Emerson D. Cale

Department of the Navy

June 29, 1984

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350

IN REPLY REFER TO

29 June 1984

Mr. Richard Gunkel
Institute for Defense Analyses
1801 Beauregard Street
Alexandria, VA 22311

Dear Mr. Gunkel,

I want to pass along some thoughts on the first meeting of CALS.

From the first meeting it was clear that there is a firm commitment by each of the Services to implement specific aspects of automation of Technical Information (TI). If I heard correctly, all three Services have established project offices, committed money, and people to do several things. Specifically, they are all committed to converting drawing repositories by scanning and digitizing existing drawings and are looking to receiving drawings and associated data from contractors in electronic form. Army and Air Force have a joint contract to do so. Navy s in an earlier stage but will begin conversion in about two years.

Secondly, all three are committed to bringing in hardware systems to allow presentation of technical information directly to maintenance personnel in lieu of paper manuals. Third, there is a move to computer based learning in the Services school houses. It would appear to be advantageous to have a stream in the overall architecture or strategy which is a kind of road map and or time line along which the technical and contractual issues can focus on meeting these objectives. As a structure, I suggest the idea of a set of categories be identified for which a road map can be laid out. The categories should be organized in a way which will be recognizable and comfortable to government and contractors. Perhaps a variation of the traditional logistics elements; i.e., maintenance, supply, test equipment, training, etc., and a functional expression. All data and data products are acquired from contractors to perform a function. We differ, in the Services, as to the tasks applied to the function but not in the function. For example, drawings are acquired for serveral functions; i.e., perform maintenance, reprocurement, configuration control. Perhaps we could get agreement of categories for the framework upon which the issues and problems can be identified, tracked and pursued.

Another point, I think we could use a vehicle to record agreed upon decisions, assumptions and constraints. I think overyone will begin to be more comfortable and can focus better when we see the choices and the ambiguity begin to narrow. At first it could just be a compendium of stated positions,

assumptions and decisions which would later be integrated as part of the strategy wherever they may fit. We could start with some easy ones to build on. Some very specific and some broad statements of intent or strategy. For example, I detected some conce n by industry as to the intention of the homework question on CAD systems. I think a statement regarding the sanctity of proprietary procedures, systems, and techniques in the pursuit of the overall goals would help and set bounds that will assist in getting industry cooperation. A broad statement of intent to "pursue standardization on data elements and interface rather than hardware or contractor systems" might be useful. Obviously, the homework propositions 2, 3, and 4 are the type we should document.

The enclosed study looked into the uncoordinated introduction of automation. It has some interesting comparisons and a tabulation of known uncoordinated proliferation of hardware and systems. It may be of some use.

Respectfully,

Emerson D. Cale

EMERSON D. CALE

Enclosure
(As stated)

STANDARD TO ACQUIRE TECHNICAL INFORMATION IN DIGITAL FORM AND CALS DEMO ACTION

Emerson D. Cale, S. C. Rainey

Chief of Naval Operations

September 26, 1984

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON, DC 20350

IN REPLY REFER TO
26 September 1984

Institute for Defense Analysis
Attn: Dr. Fred Riddell
1801 North Beauregard Street
Alexandria, VA 22311

Fred,

Just thought I would share the enclosed NTIPP memo with you. It describes the Navy level of understanding of current technology as we try to automate technical manuals. Sam Rainey is preparing a Navy plan for implementation of this automation for me right now. I should have it next week and will share it with you. We are planning three tests of this technology in 1985. I have given these to Tom Bahan as candidates for demonstration for CALS. They are a F-14 control system to be demonstrated in the spring of 85 and a shipboard radar repeater in the summer. The third is the DDG-51 which is longer term and will get going in a year. The 85 demonstrations are a side-by-side comparison of hands on maintenance performed using old MIL-SPEC type paper manuals and a totally new, electronically authored, approach using a CRT to direct the maintenance steps.

The Navy owns the authoring system (hardware) which has been used. It has built in software to allow presentation format in microform, paper, or CRT by flick of a switch.

Incidently, Sam Rainey is compiling the Navy program descriptions you had asked for in the three Service matrix.

I will be away until 22 October but can be reached at home on weekends. Home address is 4427 Majestic Lane, Fairfax, VA 22033; home phone is 378-6009.

Sincerely,

Emerson D. Cale

EMERSON D. CALE

Enclosure
(As stated)

9 September 1983
1803:369
SCR:mb

MEMORANDUM

From: S. C. Rainey
To: NTIPP File

Subj: Standardization of Specifications for Acquisition of Technical Information in Digital/Electronic Form

1. It has been demonstrated (by NTIPP, among others) that Technical Information, (TI) text and graphics, can be prepared in the form of a digital data stream (an "electronic galley") which contains suitable embedded generic coding so that the TI can be later mastered for optimal replication in any of several media. A highly reliable non-volatile transportable medium is needed (for example, a digital optical disc) as well as a display medium (e.g., a plasma panel, electroluminescent panel, or if these both fail to prove out, a cathode ray tube). For cases where it is impractical (or uneconomical) to generate the TI directly in digital/electronic form, a scanner and raster-to-vector software can correct the material to digital/electronic form with the same results (assuming scanner technology picks up a little).

Navy 1985 to have 3 differen media format

2. But without some control from the TI customer (the various Services of the DoD primarily), a nearly infinite number of approaches to accomplishing such a result could arise: with (hundreds of different kinds of computers) X (thousands of different kinds of software approaches) X (dozens of different kinds of generic coding). In general, then, a Specification is needed, telling not only what is required, but delineating all the requirements of the signal characteristics: input/output, embedded coding, programming, and language. Such a specification would require coordination: (1) among the Army, Navy, and Air Force; (2) with industry associations (e.g., NSIA, AIA, GCA, and others); (3) with standards associations (IEEE, ISO, NBS, etc.). Then not only must a specification ensure that a usable product is provided, it must also ensure that a single type of product is received, to permit pooling of DoD archives and other TI data bases, common configuration management of TI, and uniform TI update and correction procedures. Automation technology will undoubtedly be required to enhance currently defined types of TI, drawings, test data, and many other kinds of information as yet unthought of.

3. Another tool will be required: an inspection program or an extensive software system so that a contractor's output can be tested for compliance with the specification cited above. Thus in addition to the necessity for the DoD to maintain (together with others) a Specification or Standard to accomplish the purpose of defining the required product, it also would have to maintain software and the computer facility to exercise it on, to make sure that the incoming TI meets the requirements.

4. It appears to me, however, that what the DoD does not need to maintain, or to provide to contractors, is the automated authoring program by which the digital/electronic TI is actually generated. Issue the specification describing

the requirements in detail, and let industry use whatever programs and whatever mainframes they find most practical to meet these requirements. Any Government-issued authoring program for this purpose would have the following disadvantages:

a. It would be expensive. It would require a staff of civil servants to keep the program up and running (and modify it as the occasion arose).

b. It would limit competition. No matter how broadly applicable such a program was written, there would still be many perfectly good computers and operating systems that couldn't use it without extensive modification.

c. It would lay the burden of meeting the requirements mainly on the Government and to a lesser extent on the contractor. If the Government's authoring program were used by a contractor (provided as GFE) to generate TI, how can the contractor be held responsible for a case where the TI fails to meet specifications?

5. If, on the other hand, industry is permitted (required) to develop its own authoring programs, three classes of companies will emerge:

a. Those large enough to automate the production of their own TI (many already have) in such a way as to meet specifications.

b. Software houses who already provide TI services to a host of customers who do not prepare their own TI will tool up to provide this kind of automation on a wide basis to customers who are DoD contractors.

c. Small companies (mom and pop shops) who now make commercial and near-commercial manuals, will buy their digital/electronic TI preparation from the software houses above, just as they buy other specialized services from specialized contractors (with the cost, as usual, passed on to the Government).

6. Much can be learned from the Navy's experience with the TRUMP (Technical Review and Update of Manuals and Publications) Facility at the Naval Air Rework Facility, Jacksonville, Florida. Completed in the 1970's, this highly automated in-house facility functioned successfully for almost a decade to update out-of-production aircraft manuals. When it was changed to GOCO status (Government-Owned, Contractor-Operated), costs dropped but efficiency remained about the same. Now the Navy has made the decision to rely entirely on contractors for this kind of automated TI update, applying the control to the contractor's product, but not attempting to keep operating in-house the hardware and software required to perform the TI preparation function. Other services are not yet benefiting from this lesson; for example, it looks as though the Air Force Automated Technical Order System (ATOS) is getting ready to go through the TRUMP cycle again, ten years later.

S C Raining

Copy to:

OPNAV-401E/G. Cash
NAVMAT-04342/D. Weyburn
DMSSO/J. Richardson
182/M. Culpepper

CALS DATA/SOFTWARE OWNERSHIP AND PROPRIETARY RIGHTS

H. J. Correale

McDonnell Aircraft Company

October 9, 1984

CALS DATA/SOFTWARE OWNERSHIP AND PROPRIETARY RIGHTS

1. The issue of software rights is not presently covered by the FAR. Presently, the void is filled by each administrative agency issuing its own clauses and regulations. DoD has covered this in Parts 27 of the DoD FAR Supplement and its implementing clause 52.227-7013 "Rights in Technical Data and Computer Software" (formerly DAR 7-104.9(a)). These regulations set out the rights which the Government may take in software within these two boundaries:

   a. As to software required to be originated or developed under a government contract, the Government takes "unlimited rights."

   b. As to software developed with private monies or commercial computer software, the Government takes "restricted rights" significantly restricting its use.

2. The DAR/DoD FAR Supplement scheme intends to balance out proprietary rights and the needs of the Government, and has been relatively successful in doing so. However, there is a trend to attempt to erode those rights by current legislation and pressures from Government procurement personnel.

Substantive issues include:

   a. Contractor Proprietary Rights to Software Developed Under IRAD Funds - While the Government does contribute to IRAD, the entire scheme was developed to encourage private investment by permitting the Contractor to retain proprietary rights (similar to the patent rights retention scheme). However, the argument is still being faced by Contractors by those in Government wanting to procure such proprietary items that they should take ownership to those rights. Some agencies have proffered the argument that they should take such rights in view of their portion of overhead paid to which development may be charged.

b. Government Monitoring of Rights - There is some question in the minds of Contractors as to the ability of the Government to monitor and track proprietary software in which it has acquired some rights to use for limited purposes. Additionally, the DAR and DoD FAR Supplement encourages the Government to acquire only those rights and that software necessary. However, Contractors have recently been faced with more requests for acquisition of rights in software without a predetermination having been made by the Government buyers as to what is needed. This has even occurred on R&D efforts in which it is not even known at contract inception what types of software may be required.

c. Confusion About Rights Acquisition - There has been substantial confusion as to rights obtained in software. While software documentation delivered under a CDRL becomes the Government's in one sense, even if the software is provided with unlimited rights, the Contractor retains intellectual property rights therein, including, but not limited to, the right to license usage by others. However, Contractors are finding themselves in disputes as to "ownership" granted by the various levels of rights, and, consequently, wasting time and resources protecting the residual rights.

PROPRIETARY DATA RIGHTS IN CALS

In general, proprietary data does not migrate from the product data base in CAD/CAM to the logistic support files - CALS. The prime contractor suppliers do not incorporate proprietary data in technical manuals.

Proprietary drawings are used to develop spare parts and GSE provisioning data; however, the resultant provisioning data merely identifies part numbers and general descriptions of the parts - not the how to manufacture the part.

Proprietary drawings will not reside in CALS - they will be in the CAD/CAM file. The real issue then becomes a data rights issue of the product definition in CAD/CAM.

Congress is attempting to legislate certain limitations including limits on the time duration for proprietary rights including third party review of the proprietary of the rights.

The proprietary data rights issue should be identified in our CALS report but it should be clearly stated that it is not a CALS issue. It is a CAD/CAM issue, especially when we visualize Government access to contractor's CAD/CAM file.

Summary: It should be recognized that these issues are a brief overview of a very complex series of issues. CALS is merely an additional set of software to a much larger software right issue.

CALS WHAT IT IS? WHAT IT IS NOT?

H. J. Correale

McDonnell Aircraft Company

August 1984

COMPUTER AIDED LOGISTIC SUPPORT

- o WHAT IS IT?
- o WHAT IT IS NOT!

COMPUTER AIDED LOGISTIC SUPPORT

WHAT IS IT?

COMPUTERIZING THE LOGISTIC SUPPORT

$\boxed{\text{PROCESS}}$

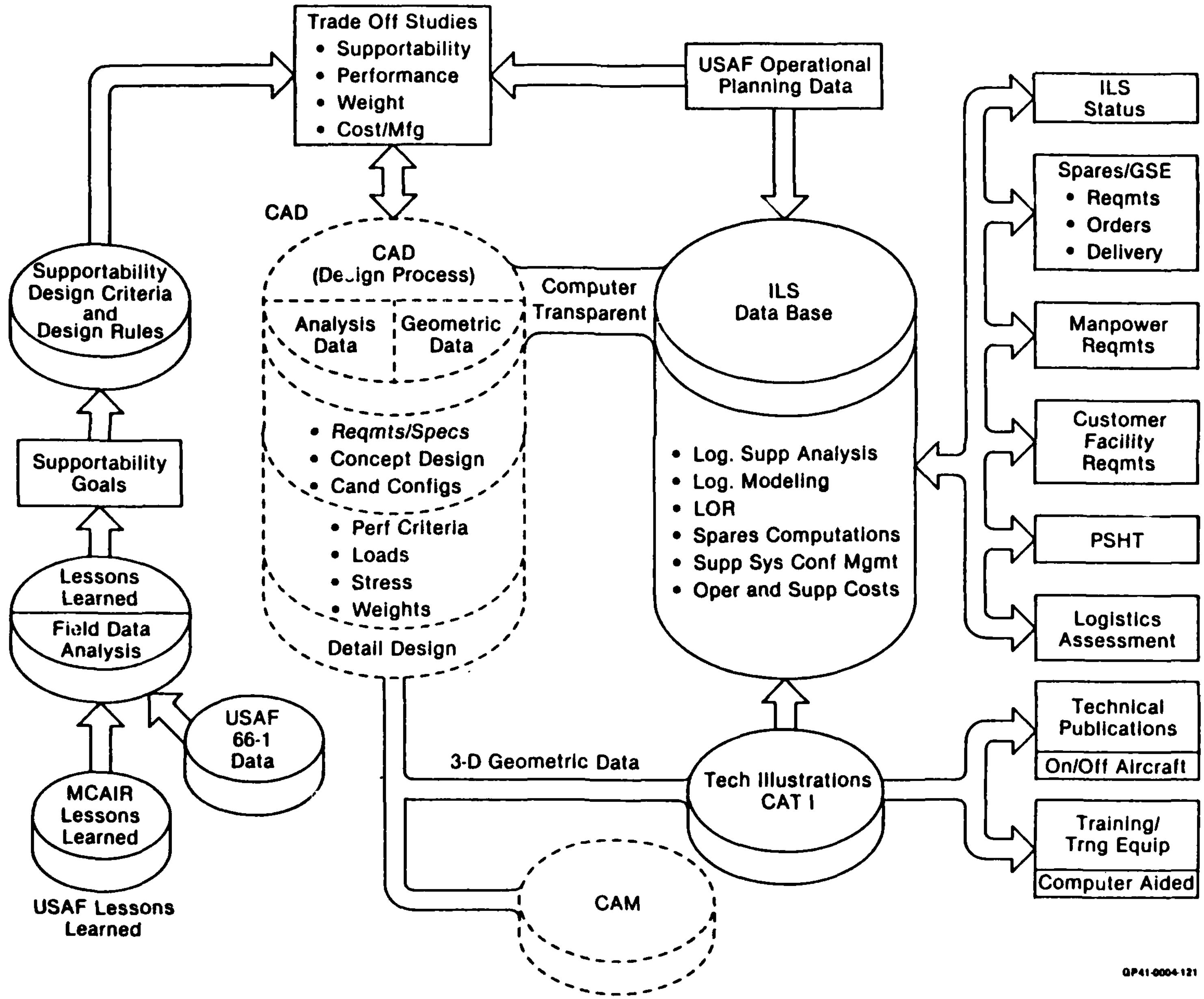
FROM

CDI ____THRU____ POST PRODUCTION

WHAT IS THE LOGISTIC SUPPORT PROCESS?

	CURRENT MEDIA		
	PAPER/ MANUAL	SOME AUTOMATION	TOTAL AUTOMATION
1. LOGISTIC SUPPORT IN DESIGN	*		
2. LOGISTIC SUPPORT ANALYSIS (LSA)	*	*	
3. LOGISTIC SUPPORT PLANNING/SCHEDULING	*	*	
4. PROVISIONING REQUIREMENTS (PUBS, SPARES, TRG, GSE, ETC.)	*	*	
5. ACQUISITION (PROCURE)	*		
6. DEVELOPMENT/FABRICATION			
o SPARES/GSE	*	*	
o PUBLICATIONS PREPARATION/PRODUCTION	*	*	
o PERSONNEL AND TRAINING	*	*	
o CUSTOMER FACILITIES	*		
o PHST	*		
7. DELIVERY	*		
8. LOGISTIC SUPPORT ASSESSMENT	*	*	

Computer Aided Logistic Support



COMPUTER AIDED LOGISTIC SUPPORT

- KEY PRINCIPALS -

- CALS MUST CONTAIN REAL TIME LOGISTIC SUPPORT PLANNING/SCHEDULING INFO.
- CALS MUST BE COMPUTER TRANSPARENT WITH CAD/CAM (PRODUCT DEFINITION).
- LOGISTIC DESIGN CRITERIA BASED ON LESSONS LEARNED AND FIELD DATA IN CALS MUST FEED THE ANALYTICAL DATA BASE IN CAD.
- CALS MUST HAVE PROVISIONS FOR LOGISTIC MODELS AND O & S COST.
- LSA SUPPORTABILITY FACTORS ($\bar{R}$,$\underline{M}$ AND LOGISTIC TRADE-OFFS) IN CAD MUST DRIVE LOGISTIC SUPPORT ANALYSIS.
- LSA APPROVED MAINTENANCE ANALYSIS IN CALS CONTROLS PUBLICATION, PERSONNEL, TRAINING, TRAINING EQUIPMENT, GSE, SPARES FACILITY REQUIREMENTS.
- CALS MUST BE CAPABLE OF ACCEPTING 3D GEOMETRIC DATA FOR TECHNICAL PUBLICATIONS AND TRAINING GRAPHICS.
- CALS SHOULD BE LINKED TO CUSTOMER FIELD DATA REPORTING SYSTEM.

COMPUTER AIDED LOGISTIC SUPPORT

IT DOES <u>NOT</u> REQUIRE

o 3D GEOMETRIC WIRE FRAME CAPABILITY

o SOPHISTICATED VDT WORKSTATIONS

o ROBOTICS - 4/5 AXIS MACHINE CAPABILITY

o RASTER TO VECTOR CONVERSION

CALS CONTRACT METHODOLOGY

H. J. Correale

McDonnell Aircraft Company

October 8, 1984

COMPUTER AIDED LOGISTIC SUPPORT CONTRACT METHODOLOGY

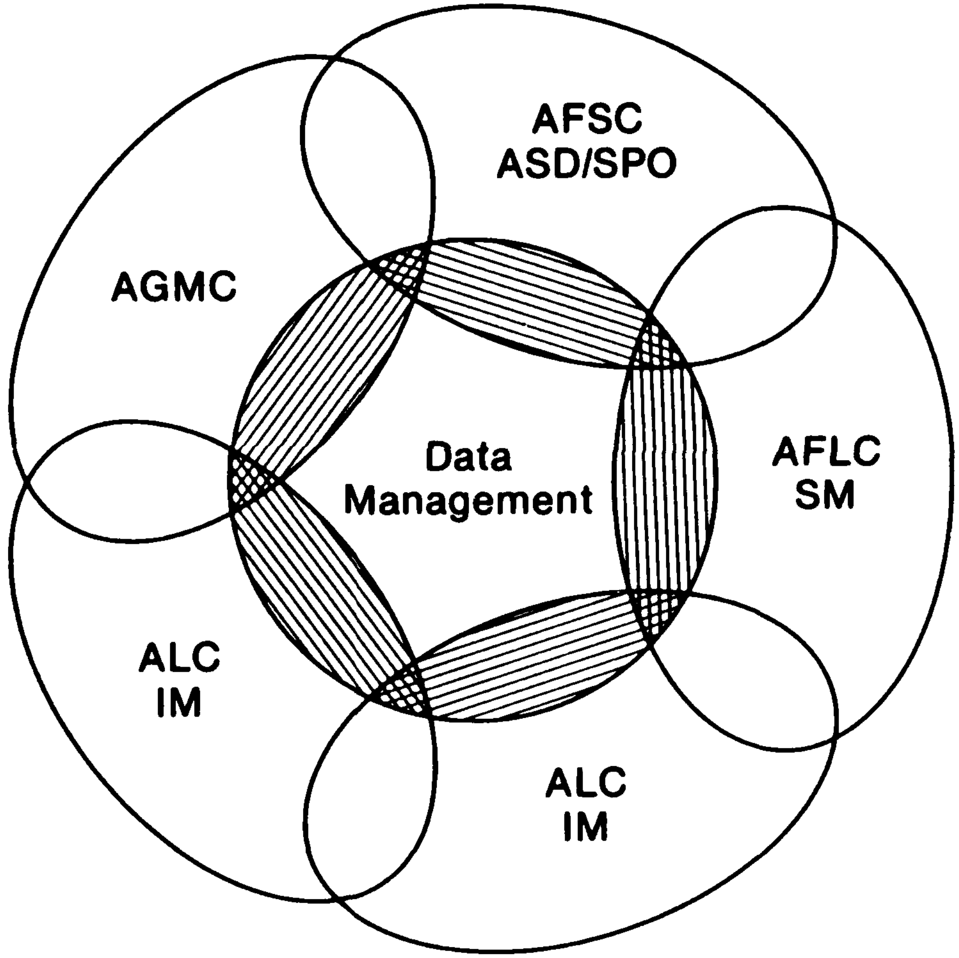
H.J. CORREALE

WHY COMPUTER AIDED LOGISTICS SUPPORT (CALS)

Implementation of the Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) concept will result in the "paperless" airplane. This concept will drastically reduce the nonrecurring manhours associated with designing and developing a new weapon system as well as reducing the development time from go-ahead to first flight. Proper emphasis on weapons system logistics support is essential for sustained combat and peacetime operations and dictates that the data available in CAD/CAM be electronically coupled to a computer aided logistics data base. The data base, in conjunction with advanced computer networks, presents opportunities for an improved "paperless" logistics support data management system.

Improved data management provides additional opportunities for increased logistics support. New data auditing and approval techniques become available, contracts could be placed electronically with the true manufacturer, file transfer from contractor to government and government to government agencies could be done electronically, reprocurement data would be immediately available and program management decisions could be based on near-real-time data accessible to government and contractor agencies. The advantages of computer aided logistics support are many and varied. In contrast, vast amounts of redundant data on current programs inundate the logistics community with paper and burden the logistics support community with attempting to find the "real" problem.

Computer Aided Logistics Support

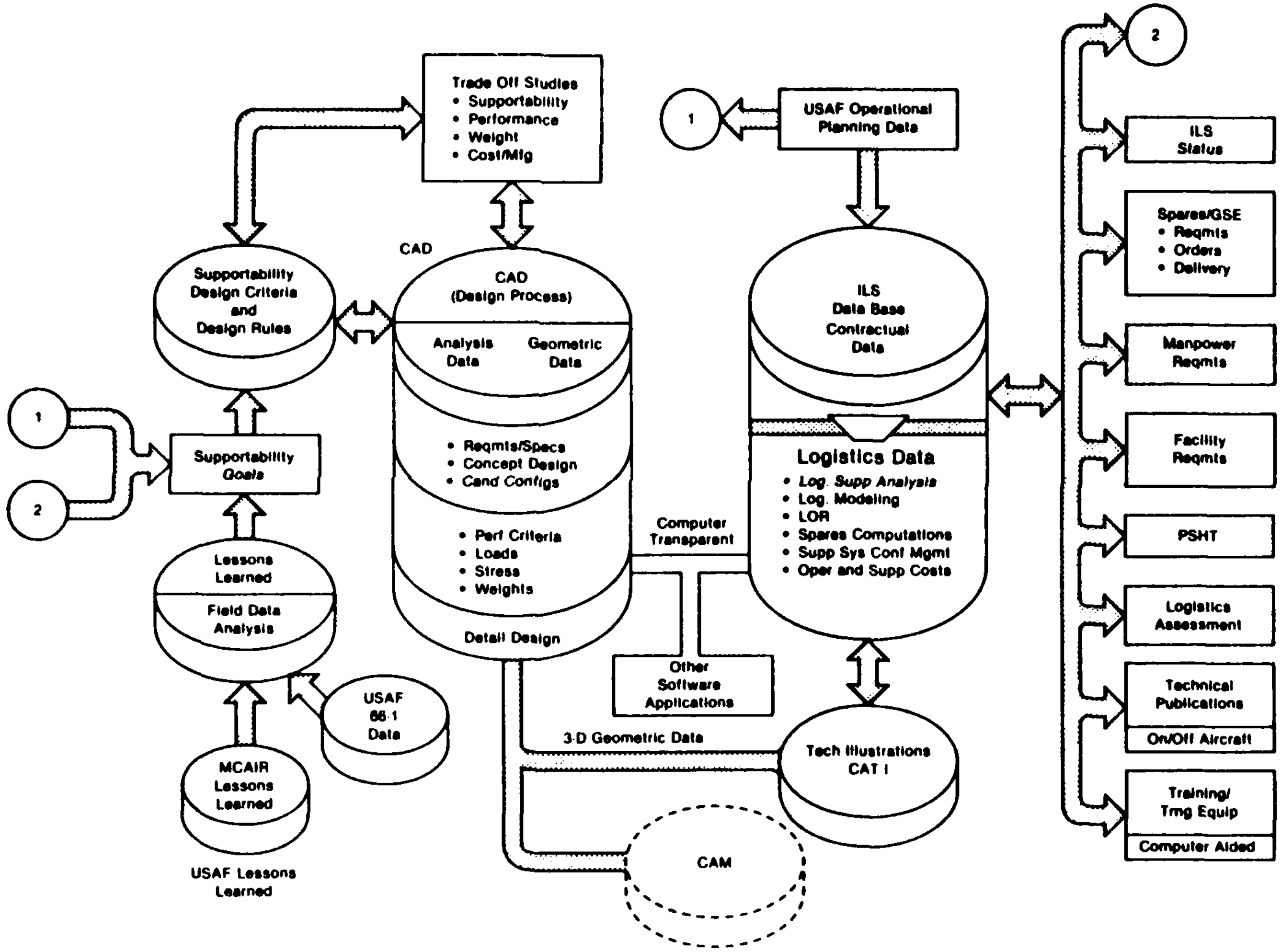


GP41-0004-131.5

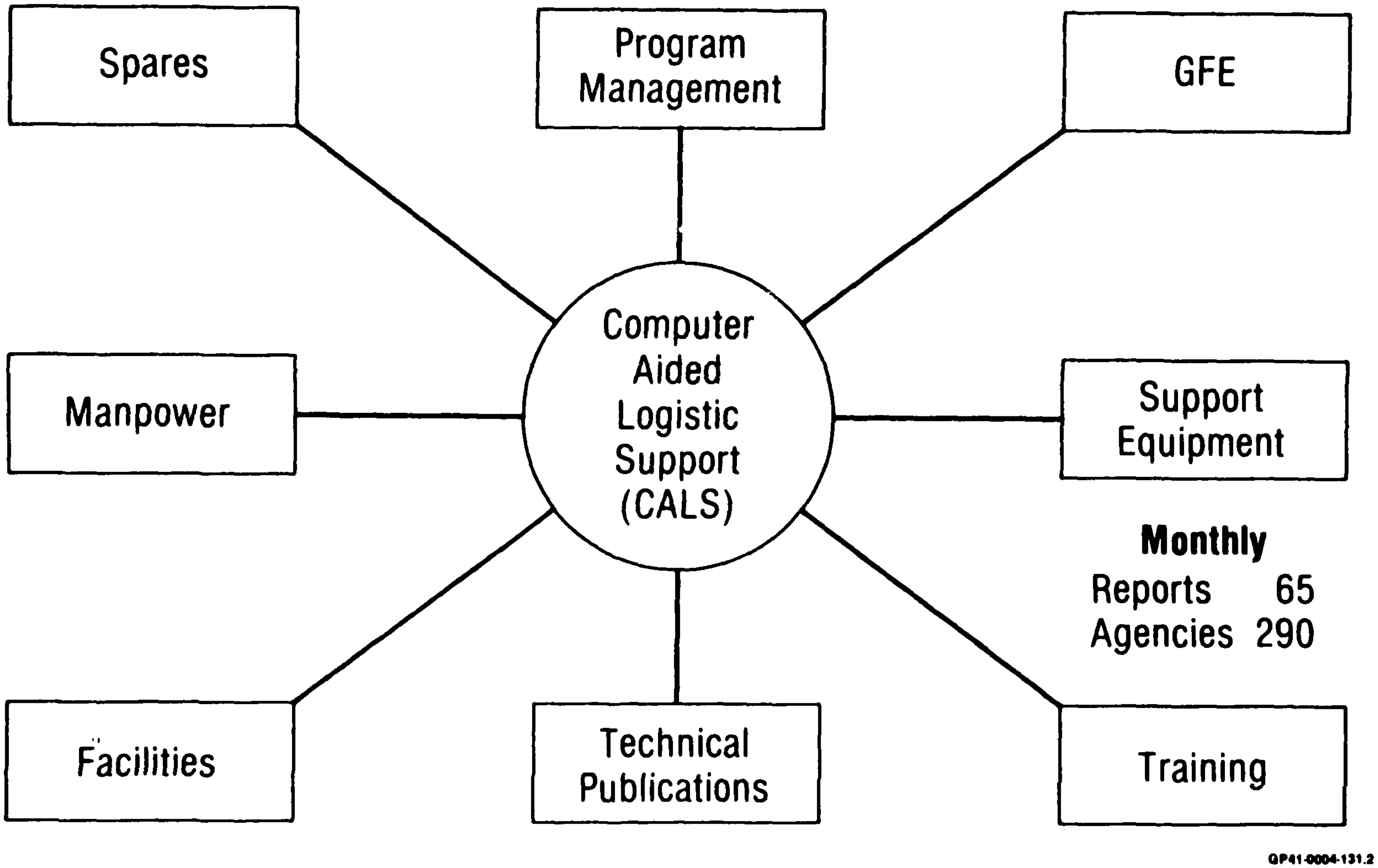
COMPUTER AIDED LOGISTICS SUPPORT

CALS is a computer program, or network of computer programs, that permits the retrieval of essential data elements stored in appropriate data banks. The design, manufacturing and logistics support data bases are interactive (computer transparent) and mutually supportive. The ILS data base contains data elements as agreed to by the government and contractor and can be electronically transmitted/called up to user viewing screens. Two-way flow of information is essential. The displayed data, in menu format, will eliminate much of the hard copy reporting required by today's CDRL's. Additionally, computer transparency permits other software applications such as automated technical manuals, training courses and program management plans. Such mass data *deliverables are possible if an electronic mail* capability (disks, magnetic tape) is provided. CALS would not permit indiscriminate data changes. "Read only" or "write" capabilities would be attached to passwords to insure the security and accuracy of data.

Computer Aided Logistic Support



Computer Aided Logistics Support



AD-A161 778 REPORT OF THE JOINT INDUSTRY - DOD TASK FORCE ON COMPUTER AIDED LOGISTIC (U) INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA F R RIDDELL ET AL JUN 85 2/2

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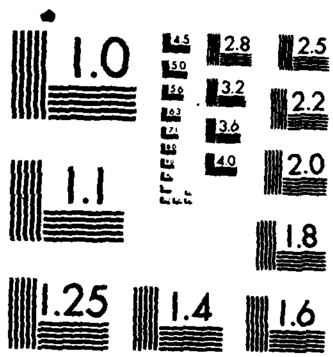
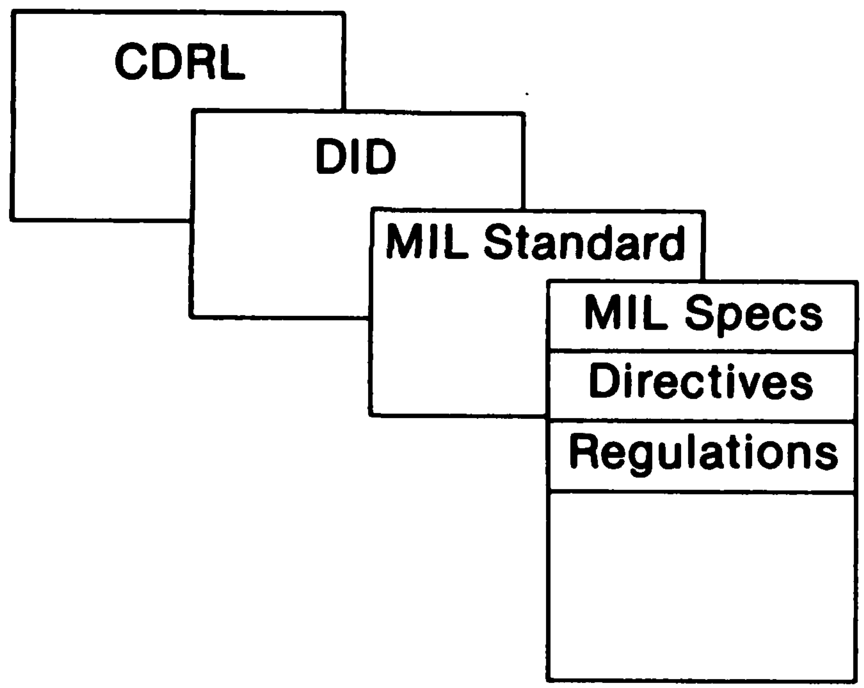


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

CALS CONTRACT METHODOLOGY

Current acquisition ground rules may not change. Directives, specifications and standards may require modification to describe CALS implementation, but they could not be eliminated. Additionally, a detailed CALS standard is required to describe standard data elements, menu selections, common terms and hardware and software compatabilities.

Computer Aided Logistics Support

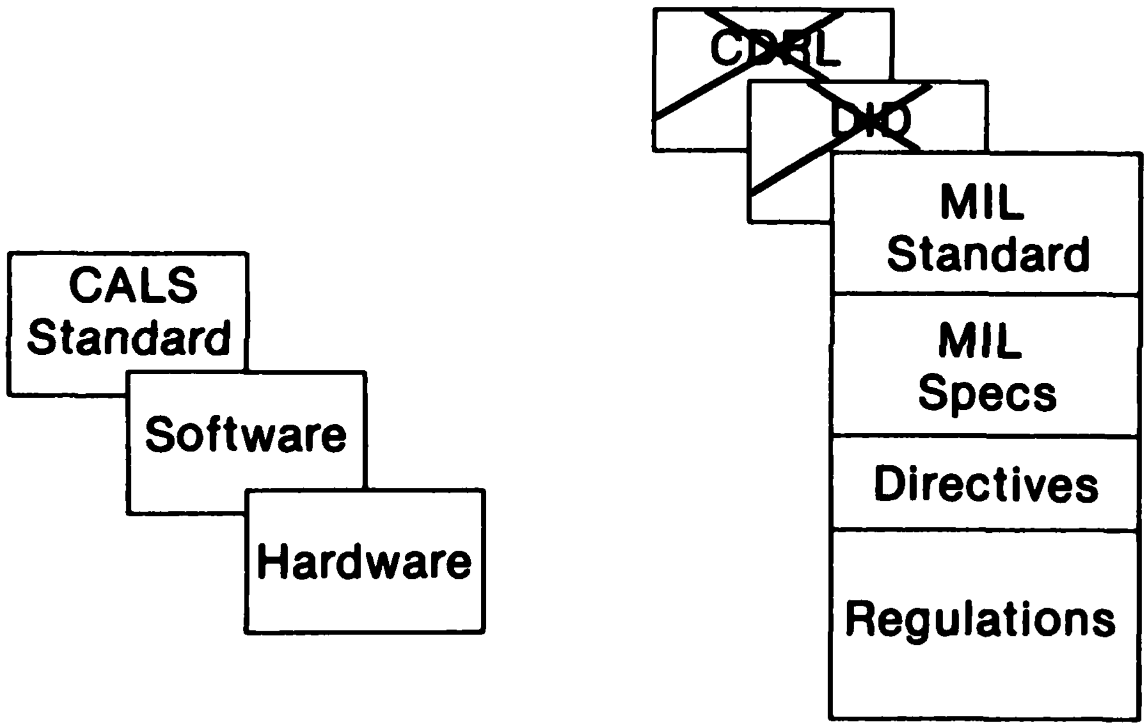


GP41-0004-131.4

CALS STANDARDS

Inherent to the effective implementation of CALS is the clear understanding of what is required by the government. Compatible data base construction and maintenance procedures are needed to insure uniformity of data elements common to more than one user. The media used to transmit data must be specified. Mass data deliverables may best be transferred by physically relocating discs or magnetic tapes possessing common data elements and data format. Frequent transfer of small numbers of data elements would be accomplished using on-line video display terminals. Maximum use of embedded software routines could be used to tailor repetitive reports to a common format. Up-front equipment standards will insure maximum equipment compatability.

Computer Aided Logistics Support



GP41-0004-131.3

CALS STANDARDS

There are four specific considerations for CALS standards development:

CALS Database Standard - Prescribes standard practices for:

Database Development - Types of storage media and method of storage (direct or indirect).

Data Element Addressing - Standardized approach to addressing data elements within the data base.

Interactive Capability - Standardized architecture to facilitate communications between databases. Includes security considerations.

CALS Media Standard - Prescribes standard procedures for data transmission:

Disk or magnetic tape data transfer,

Format of desk/magnetic tape data,

On-line access to database via CRT.

CALS Software Standard - Prescribes common data requirements and data element extraction routines:

Defines common inter-service needs,

Standardizes programming language and techniques,

Ensures required data elements are transmitted to the specified user.

CALS Hardware Compatibility Standards - Prescribes hardware compatibility guidelines:

Ensures interactive compatibility between contractor and government,

Ensures hardware will supply user needs,

Ensures transfer of large scale database from contractor to user.

COMPUTER AIDED LOGISTICS SUPPORT (CALS)

CALS STANDARD

- DATA BASE:
  - STORAGE, RETRIEVAL, SECURITY
- MEDIA:
  - DISK, MAGNETIC TAPE, ON-LINE, FORMAT
- SOFTWARE:
  - PROGRAM LANGUAGE, DATA ELEMENTS
- HARDWARE:
  - CONTRACTOR/GOVERNMENT COMPATIBILITY

CALS IMPACT

Contractor Benefits - The Logistics Support Analysis (LSA) begins with "design to" supportability requirements levied on the designer. This is done through the CAD system so the designer can incorporate the required supportability features during the design process and establish supportability data elements in CALS. Specific supportability design rules and algorithms must be included in CAD.

Acquisition of Logistics Support - Item Manager - Once the maintenance plan is approved, each Government Item Manager (spares, support equipment, tech pubs, training equipment, etc.) has access to the defined logistics support resources resident in CALS. With appropriate prior approval, use of this data could expedite preparation and justification of purchase requests. Additionally, government procurement agencies and competition advocates could use the CALS data to validate the purchase order and reduce procurement processing time. GOVERNMENT IMPACT - Establish methods for using computer data to expedite approval of purchase orders. Where possible, government procurement agencies should have the capability to place electronically transmitted contracts with the true manufacturer. INDUSTRY/CONTRACTOR IMPACT - Develop methods for receiving and processing electronically transmitted government orders for logistics support.

CAD/CAM In A Competitive Environment - Reprocurement data packages will reside in the CAD/CAM file. Government procurement agencies could have immediate access as an aid to increased competition for logistics support resources. GOVERNMENT IMPACT - Reduce the cost of acquiring and maintaining reprocurement data packages. The reprocurement data file would simplify government transition from CFAE to GFAE during the production cycle after system maturity and design stability is attained.

Data Audit/Approval Techniques - As paperless logistics support becomes available, improved data auditing and approval techniques can be developed. Data auditing in this context refers to assuring that integrated logistics support is in concert with the approved maintenance plan. This auditing could be done with appropriate edit and compare programs. The approval techniques refer to the requirement for government approval of the maintenance plan upon which the support system is built. The historical process of delivering multiple copies of literally thousands of pieces of paper for review and mark-up would be replaced by the CALS continuous flow of electronically transmitted data. CONTRACTOR IMPACT - Develop new techniques for using remote access/job entry terminals with on-line update capability.

Data and File Transfer - At the appropriate time, the contractors' data files would be transferred to appropriate government agencies. CALS can interface with the Air Force Requirements Data Bank and continuously update selected data elements. It should be recognized that the prime contractor's data will be eventually transferred to the AFLC System Manager (USAF). Early provisions for establishing unique, on-line weapon system files for inventory managers would negate the requirement for recreating files to effect data transfer. Additionally, file-to-file transfers among government agencies would be extremely beneficial during Program Management Responsibility Transfer (PMRT). CONTRACTOR/GOVERNMENT IMPACT - In the near term, government would have to accept selected prime contractor data bases using common data access terminals. Long term, government must describe/develop CALS standards and provide for updating files as a result of post production design changes.

COMPUTER AIDED LOGISTICS SUPPORT - IMPACT

- CONTRACTOR BENEFITS
- GOVERNMENT BENEFITS
    - PROGRAM MANAGEMENT
        - NEAR-REAL-TIME MILESTONE STATUS
        - SAVES TIME AND COSTS
            - REDUCES MEETINGS
            - ELIMINATES DUPLICATION
    - ITEM MANAGEMENT
        - JUSTIFY PURCHASE REQUESTS
        - CURRENT REQUISITION/DELIVERY STATUS
        - REPROCUREMENT DATA
    - PROCUREMENT
        - VALIDATE PURCHASE REQUEST
        - TRUE MANUFACTURER
        - ELECTRONIC ORDERS
        - STATUS OF ORDERS
    - USER
        - INCREASED LOGISTICS SUPPORT

SUMMARY

A computer network that provides accurate, near-real-time information to program managers is a big step towards insuring weapons system acquisition on-schedule and on-cost. The logistics community's increasing role in the acquisition process can best be served by the opportunities offered in a well defined Computer Aided Logistics Support Program. Ultimately, this improved logistics capability will be seen where it counts most, in the operational environment.

COMPUTER AIDED LOGISTICS SUPPORT

<u>SUMMARY</u>:

CALS IS NEEDED TO SUPPORT: PROGRAM MANAGERS
PROCUREMENT MANAGERS
LOGISTICS MANAGERS

BECAUSE IT IS:

AN UP-TO-DATE MANAGEMENT TOOL.

COMPUTER-AIDED LOGISTICS SUPPORT INDUSTRY AND GOVERNMFNT

H. J. Correale

McDonnell Aircraft Company

October 30, 1984

COMPUTER AIDED LOGISTIC SUPPORT (CALS)
"A PAPERLESS LOGISTIC SYSTEM"

General

Implementation of the Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) concept will result in the "paperless" airplane. This concept will drastically reduce the nonrecurring manhours associated with designing and developing a new weapon system as well as reducing the development time from go-ahead to first flight. The CAD/CAM data, electronically coupled to the computer-aided logistic data base in conjunction with advanced computer networks, presents opportunities for a "paperless" logistic system. However, before that can happen, a definite change in mind set and funding procedures will be required. Logisticians are sometimes referred to as "paper pushers" and upon examination of the current procedures, this is probably a fairly accurate assessment. Computer Aided Logistic Support, with the vast amounts of data contained therein, will inundate the logistics community with paper and bury any logistics support program unless steps are taken to maximize the use of this tool.

WHAT"S THE IMPACT OF CALS?

Logistics Design

The Logistic Support Analysis (LSA) process begins with "design to" supportability requirements levied on the designer. This must now be done through the CAD system so that the designer can incorporate the required supportability features during the design process. CONTRACTOR IMPACT - Specific supportability design rules and algorithms must be included in CADD.

Data Audit/Approval Techniques

As the paperless logistic system comes on-lime, new data auditing and approval techniques must be developed. Data auditing in this context refers to assuring integrated logistics support, i.e., all support elements are in concert with the approved maintenance plan. Most of this auditing can be done

with appropriate edit and compare programs. Another form of auditing is that required to certify the contractor's capability to perform the LSA function. The approval techniques refer to the requirement for up front Government approval of the basic maintenance plan upon which the support system is built. Historically, this has involved the delivery of multiple copies of literally thousands of pieces of paper for manual review and markup. CONTRACTOR IMPACT - A new technique utilizing remote access/job entry terminals with on-line update must be developed.

Logistic Support Element Acquisition

Once the maintenance concept is approved and the logistics support resources are identified, how will acquisition be accomplished? Will each logistics support element manager in the Government, i.e., spares, support equipment, technical publications, training equipment, etc., still require their own peculiar paperwork for review and approval prior to acquisition? If so, it would certainly seem redundant in that the maintenance plan has already been approved, and again, we would not have a paperless logistic system. LSA maintenance plan has defined the required logistic support resources, how will they be transmitted to the customer? We will revert back to paper. GOVERNMENT IMPACT - In the LSA environment, the logistics support requirements derived as a result of a Government approved maintenance plan should be transmitted electronically to the appropriate Procurement agency and where the capability exists, the contract placed electronically with the true manufacturer. INDUSTRY/CONTRACTOR IMPACT - Government agencies must change their procedures to process logistic support requests and issue purchase orders electronically. This will eliminate the need for a large number of government employees.

Data and File Transfer from Contractor to Government Agency

At some point in time, the contractors' developed CALS will be transferred to a Government agency(s). Issues to be addressed here are the method of transferring (i.e., on-line computer vs mag tape, etc.) and the degree of software standardization

required. Through interface with the Air Force Requirements Data Bank, a Computer Aided Logistics program could be continuously updated. In the long term, Government needs to define their logistics data base requirements and integrate these with their systems, i.e., USAF Requirements Data Bank. In the near term to capitalize on emerging technology, DoD should recognize that the prime contractor's data base will be transferred to the Logistic System Manager, i.e., SSM in USAF so that the will NOT have to recreate a weapon system file. The inventory managers (IM's) can operate on-line with the unique weapon system file. When the Government ILS Data Bank was defined, each contractor will format his data for direct transfer to the Government as the product ends its production cycle. CONTRACTOR/GOVERNMENT IMPACT - In the near term (next five years), the Government would have to accept selected prime contractor data bases using common data access terminals. Government must develop common logistic data base elements so that the near term files could be transferred to the Government owned and operated data base. Provisions for updating the file as a result of post production design changes (Government/contractor initiated) must be established.

Utilization of CAD/CAM Data in a "Competitive" Environment

In the CAD/CAM environment, reprocurement data packages as they are known today will be nonexistent. The data will reside in the file. Government access will immediate to help increase competition for logistic support resources. GOVERNMENT IMPACT - Eliminate the cost of acquiring and maintaining reprocurement data packages. The reprocurement data in CAD will also simplify Government transition from CFAE to GFAE during the production cycle after system maturity and design stability is attained.

Summary

The impacts contained herein are just a few of the more burning issues related to CALS and by no means are intended to represent all of the Government/contractor areas of impact.

RECOMMENDATIONS FOR IMPLEMENTING ACTION ON GRAPHICS AND TEXT STANDARDS

B. Lepisto

June 17, 1985

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1. <u>EXECUTIVE SUMMARY</u>. Information processing technology for automated creation and delivery of product definition and technical data is being adopted throughout the defense industry. Use of standard languages and data exchange formats is not necessary for digital/electronic transfer of graphics and text data. However, such use is essential to effectively capitalize on the cost reduction opportunities that computer technology offers for weapon system acquisition. Industry recognizes the value of standardization, and is contributing to the development of a variety of language and data exchange standards. Some of these standards can be used to help satisfy DoD objectives to improve the effectiveness and efficiency of weapon system acquisition and life cycle management. DoD should announce its support for these standards. Some of the standards exhibit deficiencies, which active DoD support and funding can remedy; others have a plan for evolutionary development, which DoD support can accelerate. The Computer Aided Logistics Support (CALS) study has already highlighted DoD's need to interface these standards in a wholly integrated logistics support structure linking weapon system designer to weapon system manager and users. Principal standardization findings developed in this paper are:

a. A few of the various text and graphics standards are sufficiently complete and widely enough accepted that a formal DoD commitment to their use should be made immediately.

b. DoD should target funding to development, validation, and demonstration of industry standards where shortcomings or unknowns preclude such a formal commitment at this point in time, but where potential benefits appear substantial.

c. Standards integration requires more attention, more emphasis, and more hands-on application experience to take full advantage of standardization opportunities.

To implement these findings, DoD should charter a lead Service project office to coordinate the further development, demonstration, and implementation of industry graphics and text standards. DoD should adopt the Standard Generalized Markup Language (SGML) for text processing and the Graphics Kernel System (GKS) for two-dimensional graphics in early 1985. DoD should also announce its intention to actively promote further development of the Initial Graphics Exchange Specification (IGES) for CAD/CAM product definition transfer, and should adopt the Product Definition Exchange Specification (IGES' successor) following its December 1985 release by the National Bureau of Standards. DoD should fund further IGES development and the development of standards interfacing capability, as well as a series of demonstration projects applying these standards for CAD/CAM data delivery and automated authoring of technical documentation.

2. <u>DESCRIPTION AND OVERVIEW</u>. Graphics and text standards provide a common medium for either generation or transmission of

graphics and text data. Common media provide the data, program, and programmer portability necessary to improve automated data processing (ADP) efficiency and reduce the cost of sharing weapon system acquisition data among prime contractors, sub-contractors, and vendors, as well as between defense contractors and DoD. ADP systems in use today still remain significantly hardware and software unique; this is especially true of the Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) systems and the large-scale automated technical documentation authoring systems needed to support weapon system acquisition programs. Often, two systems produced by the same manufacturer are so different that they cannot communicate directly with one another, let alone with another manufacturer's CAD/CAM or authoring system. Graphics and text standards provide a vehicle for accomplishing such communication, or for sharing the data produced by such systems. There are nearly fifty national and international organizations, industry and professional associations, and other groups involved in the development and review of standards in these areas.

2.1 Types of Graphics and Text Standards. Not all standards serve the same purpose, just as not all accomplish the same range of functions. This is important not only in understanding how a standard should be used, but also in understanding the limitations on its use. One type of standard specifies a language grammar, which allows program (and programmer) portability between ADP systems. Ada, the new programming language developed by DoD, is such a standard. Program source code written in the American National Standards Institute (ANSI) standard for Ada can be run on any computer for which an Ada compiler has been written and validated; the compiler translates the standard, machine-independent Ada source code into non-standard, hardware-dependent object code. Somewhat like Ada, GenCode is a standard language grammar for text markup and identification. Another type of standard provides a common file structure for exchanging data between application programs operating on different ADP systems. The programs themselves may be in different languages, but each uses a system-unique translator to produce and read a data file that is in a common format which both can understand. The Initial Graphics Exchange Specification (IGES) for CAD/CAM product definition is a standard of this type. Neither standard languages nor standard exchange formats are necessary for transfer of graphics or text data, and some degree of interchange capability exists without such standards. But standardization is essential to achieve real productivity benefits; indeed, without the use of such standards, widespread networking among multiple contractors and DoD components would be cost prohibitive.

For purposes of organization, this paper makes a primary distinction between language and file structure standards for graphics and text. A subsequent distinction is also drawn between CAD/CAM and authoring system standards. Other organizations of this paper would be possible, because many of the standards addressed here do not fit cleanly into a particular category. For example, IGES is intended to evolve into a "pro-

duct definition" standard that is much more than simply a graphics file structure; VDI (CGI), the Virtual Device or Computer Graphics Interface, is a hardware interface standard for software as much as it is a language standard; NAPLPS, the North American Presentation Level Protocol Syntax, which is here classified as a file structure standard, is a data representation "product definition" standard that is much more than simply a graphics file structure; VDI (CGI), the Virtual Device or Computer Graphics Interface, is a hardware interface standard for software as much as it is a language standard; NAPLPS, the North American Presentation Level Protocol Syntax, which is here classified as a file structure standard, is a data representation standard with some language characteristics that depends on the implementing system for the exact format of the file in which the NAPLPS data stream is stored. While a standard language (incorporating a standard file format) has advantages over a standard data transmission format alone, it is often more difficult to obtain agreement on, particularly during a period of technology emergence. Both types of standards require hardware-dependent translators, even when advertised as device independent, and those for data transmission can be harder to develop and validate because the range of potential data cases created by different languages is much broader than the range of a single language instruction set.

2.2 Graphics Standards. Graphics applications for the computer have evolved in part from industrial design requirements, and in part from consumer delivery requirements, including publications, broadcast advertising, and game/microcomputer visuals. Graphics standards are still developing. Except for the North American Presentation Level Protocol Syntax, or NAPLPS (which has some deficiencies), none are complete or fully accepted, and there are still many hardware/software unique graphics languages and formats in use. Few DoD organizations employ computer graphics software that conforms to a proposed or de facto standard. Some graphics languages are being pushed as de facto standards, through free or low cost licensing by the developer to potential users, in the hope that a broad enough base of support will emerge to force official sanctioning by a standardization body such as ANSI. In some cases, competing standards are being developed, with survival expected to go not necessarily to the fittest, but perhaps merely to the first available. Since graphics applications have little value in isolation, graphics languages and data transmission formats must include "hooks," or bindings, to languages/formats for alphanumeric text and scientific data. It is important that these, too, be standardized to facilitate program portability.

2.2.1 Graphics Language Standards. There is no standard graphics language for major industrial applications such as CAD/CAM, because hardware investment costs are still high enough to discourage the equipment proliferation which tends to break down barriers between proprietary, competing software. Therefore, graphics language standards focus on lower cost micro and minicomputer applications, including automated authoring systems,

simple word processing systems, and personal computers. Even when mainframe hardware is used, graphics requirements for these applications also tend to be much simpler than for CAD/CAM systems, making a standard graphics language easier to develop. The leading contenders for graphics language standards are CORE, PMIG, GKS, VDI and PHIGS.

2.2.1.1 CORE. CORE is a de facto standard developed between 1974 and 1977 by the Special Interest Group on Graphics of the American Association for Computing Machinery. It supports three-dimensional graphics, but does not directly specify higher level language bindings, thus hindering transportability. Although no longer universally viewed as "the emerging industry standard," CORE is still being advocated and used in many graphics systems. Work on development of CORE significantly declined with the emergence of the Graphics Kernel System (GKS).

2.2.1.2 PMIG. (Programmer's Minimal Interface to Graphics) was begun in 1979 as an effort to make a less sophisticated version of CORE available to personal computer users and BASIC programmers. Some work continues on PMIG, although most efforts ended when GKS was adopted as an International Standards Organization (ISO) working item. PMIG concepts have been incorporated into GKS.

2.2.1.3 GKS. (Graphics Kernel System) is the current leading contender for an international industry graphics language standard. Initiated in Germany in the late 1970's, it has generally absorbed effort earlier applied to CORE and PMIG. A complex two-dimensional language with standard bindings for intersystem transportability, it handles both vector and raster graphics, and has the capability to zoom in and pan across large, sophisticated graphics such as might be developed for technical publications.

2.2.1.4 VDI. (Virtual Device Interface, recently renamed the Computer Graphics Interface, or CGI) is a different kind of graphics language standard. Whereas CORE and GKS provide application program interfacing but require complex machine-unique device driver/translators, VDI is being developed specifically to address the device interface problem. VDI will utilize much simpler machine-unique device drivers which may eventually be provided through a standard hardware connector. Still under development, VDI is expected to be less complex, and hence faster, than GKS. Most programmers will employ sophisticated graphics languages such as CORE, GKS, and PHIGS that use VDI device drivers; few will use VDI directly.

2.2.1.5 PHIGS. (Programmer's Hierarchical Interactive Graphics Standard) is a "standard of the future," the first planned graphics language standard which may be usable for CAD/CAM applications. Presently an ANSI and ISO working item offering draft approaches to resolution of CORE and GKS deficiencies, PHIGS is planned to be a partially compatible extension of GKS with addi-

tional levels (hierarchies) of building blocks, three-dimensionality, faster response time, and lower overhead requirements.

2.2.2 Graphics File Structure Standards. In the absence of a hardware independent standard graphics language, a standard data exchange format provides the best common medium for multi-user sharing of graphics data, such as commonly occurs among prime and subcontractors involved in CAD/CAM for a major weapon system. Of course, nonstandard direct translators between graphics systems can be used for data exchange. However, the development cost for such translators becomes prohibitive as the number of unique graphics systems proliferates. Standard data file structures also require translator development, but only need translators between the unique graphics system and the standard format, not between the unique graphics system and every other unique graphics system. On the other hand, translator development cost (and time) savings can be offset by complexity problems requiring extraordinary attention to translator validation. The standard data file structure must be as rich - meaning as sophisticated, even if not as complex - as the most sophisticated system with which it interfaces, or it may not be able to adequately represent the full range of graphics data passed to it, nor accurately communicate that data through another translator (usually written by an entirely different team of programmers) to another graphics system. Hence, standard file structures for graphics data are easier to develop for simple graphics languages; a data exchange standard for CAD/CAM systems exists, but is still incomplete and imperfectly implemented. The three principal candidates for file structure standards are NAPLPS, VDM, and IGES, each of which has a different community of interest.

2.2.2.1 NAPLPS. (North American Presentation Level Protocol Syntax) was developed for the videotex market during 1981-82, based on a series of European and Canadian efforts dating back to the mid-1970's. It primarily provides two-dimensional text and graphics transfer through the use of redefinable control and graphics character sets. Its wide versatility makes it popular for a variety of graphics communication and broadcast applications. It is a data representation standard with some language characteristics, rather than a file structure standard.

2.2.2.2 VDM. (Virtual Device Metafile, recently renamed the Computer Graphics Metafile, or CGM) is a storage/communications medium specifically oriented to graphics, developed since 1980 as a complement to GKS and VDI. It is still in the draft stage, and just as existing hardware-unique data transfer formats have many VDM-like features, so does NAPLPS, which is more popular than VDM in the graphics community. What VDM offers that NAPLPS lacks is a standard storage format. Like VDI, VDM development is not directly linked to development of GKS. However, because it has been designed to interface with GKS and VDI, VDM may achieve the support GKS now has, although it has not done so as yet.

2.2.2.3 IGES. (Initial Graphics Exchange Specification) is a neutral data format for product definition data (including both geometry and technical information) generated in the CAD/CAM world, as opposed to simpler NAPLPS and VDM "picture transfer." Development began in 1979, with several versions already released, but remains incomplete and principally oriented toward mechanical applications. IGES deserves the significant attention it is receiving because it is the only meaningful American standardization effort underway in the CAD/CAM world. However, the complexity of CAD/CAM graphics makes development of accurate, verifiable translators to and from the neutral IGES format a major problem to be overcome, to which the IGES development committee, vendors, and users have not yet applied adequate attention. Another problem only beginning to be seriously tackled is the development of interface translators between IGES-formatted CAD/CAM graphics and the graphics standards for delivery/presentation systems (eg, GKS language or VDM file format standards) which would be used for illustration of technical manuals.

2.3 Text Standards. Efforts to develop text standards for the publishing and typesetting industries have a long history, but standardization of languages and formats for automated authoring systems is of much more recent advent. The "simplicity" of text and the availability of ASCII (American Standard Code for Information Interchange) coding used in teletype communications and a wide variety of computer applications slowed standardization of authoring system software. This allowed time for widespread proliferation of vendor-unique text processing systems, many of which employ elaborate control code schemes to satisfy demands for user friendliness and special output formatting. The difficulty of exchanging these non-standardized control code structures among dissimilar text processing systems provided the pressure necessary for development of text standards, although the significant user investment in text processing hardware has encouraged manufacturers to continue attempting to establish their own unique systems (such as IBM's Document Content Architecture or XEROX's Interscript) as de facto standards. ISO's Office Document Architecture standard may eventually emerge as the principal contender among a variety of standardization efforts in the text processing arena. However, for the near term, there are essentially only two community-wide text standards exist in nearly completed form that DoD should consider; these are SGML, together with its precursor GenCode, and DIF.

2.3.1 SGML. (Standard Generalized Markup Language) is a method for coding text files which separates document content from the processing instructions that define the output form and format of the document. The concept of a markup standard is over fifteen years old, but SGML itself is fairly recent, and is still awaiting final adoption. It is a text processing language largely based on GenCode, a trademarked generic coding structure developed by the Graphic Communications Association, which is in widespread use. SGML/GenCode by itself describes the coding of the document structure, but not the processing or appearance of

the marked up document. Nor is it a complete office document architecture because an SGML implementation includes a language, not merely a coding structure, it can be easily linked to other languages, such as GKS, for which specific binding provisions are being incorporated in the SGML standard. However, SGML does not provide a mark-up capability for these incorporated graphics. SGML provides a device-independent syntax for using text coding identifiers defined by the user, which are then interpreted by a device-dependent preprocessor.

2.3.2 DIF. (Document Interchange Format) is a less sophisticated neutral data exchange format for text. DIF utilizes translators to convert system-unique text processor control coding to and from the DIF representation, similar to the way IGES acts as a data exchange format for CAD/CAM systems. DIF is attractive to those who have large investments in existing proprietary text processing systems which must communicate with other proprietary systems. Unlike IGES, however, DIF can be seen as a short term standard, since the growing acceptance of SGML/GenCode for new text processing systems may be expected to gradually displace the DIF market.

2.4 Merging Text and Graphics Standards. In today's automated world, neither graphics nor text is used in isolation, except on the simplest word processing systems. Eventually, a joint graphics and text standard such as ISO's Office Document Architecture may emerge, although that day is a long time in the future. Graphics standards which provide for encoded text attributes such as IGES, text standards which allow block insertion of graphics such as SGML, and dual-form transmission formats such as NAPLPS, are the nearest current approach to a joint standard. Hence, if the objective is to integrate both text and graphics for CAD/CAM and automated authoring, a combination of standards will have to be considered. Translators or internal bindings will be needed to link text/graphics data or application programs. This is true whether graphics and text data is stored in a single, integrated data base, or in separate data bases linked through data base management system pointers. To the extent translators and bindings must be developed, test and validation will become an important and costly issue.

3. DOD OBJECTIVES. The Joint Industry/DoD Task Force on Computer Aided Logistics Support is defining a set of DoD objectives which focus on the use of existing and emerging computer technology to enhance the current process for designing more supportable weapon systems, planning better support for those weapon systems, improving the timeliness and quality of logistics support throughout the system life cycle, and reducing the cost of weapon system acquisition and support. These objectives have to be achieved within the framework of a network of prime contractors, subcontractors, vendors, and government activities who must exchange a broad spectrum of technical data about each weapon system. This includes product definition, manufacturing process, configuration management, training and maintenance, and other

logistics support data. Graphics and text standards provide a vehicle to support and facilitate actions undertaken to achieve these objectives. Proliferation of non-standard or proprietary data exchange techniques can seriously impede accomplishing these objectives. Because the United States is several years ahead of other nations in implementing computer technology in these areas, it is imperative that DoD vigorously support the appropriate standardization initiatives.

3.1 Principal Goal. The principal goal of the Department of Defense that is relevant to the issue of graphics and text standards should be to improve the capability of defense contractors and the Military Departments to exchange digital data among different CAD/CAM, automated authoring, drawing repository, and configuration management systems. Neutral data transmission formats supported by validated translators represent a minimum requirement for meeting this goal, since long-term proliferation of direct system-to-system translators is both impractical and cost prohibitive. Common languages (incorporating or supported by neutral data exchange and storage formats) represent a preferred alternative, since these improve program portability and programmer productivity. Data base management standards and common communication protocols, or protocol bridges, at the lower levels of the International Standards Organization (ISO) Open Systems Interconnection model, will also be needed, but are not addressed by this paper.

3.2 Specific Objectives. This DoD goal translates into more specific objectives, as follows:

a. Improve the ability of defense subcontractors and prime contractors to share/exchange CAD/CAM data, to provide product definition data in a common format to the Military Departments, and to archive CAD/CAM and product definition data in a neutral, hardware transparent format that is retrievable and usable on later generations of computer equipment.

b. Encourage use throughout the defense industry of automated authoring capabilities, such as those widely used in the publishing community, for preparation, update, and delivery of technical documentation throughout the weapon system life cycle.

c. Ensure the capability to implement a CALS system architecture which maximizes the concept of "single-point entry" of graphics and text data into an automated delivery/retrieval system. Satisfying this objective would involve the ability to communicate product definition and graphics data in digital form from CAD to CAM systems, and from these systems to engineering drawing repositories/archives, configuration managers, engineering support activities, and authoring systems for technical manuals, training publications, and maintenance/operator aids. Similarly, textual data would be passed from design/manufacturing to logistics support analysis, and to publication authoring. At

each point the content of the data might be expanded, changed, or compressed, and the form might be revised, but the requirement for re-input of data previously created would be eliminated.

d. Provide for electronic delivery of weapon support data to all users in a secure environment, to improve data quality and timeliness, and to more efficiently manage the large volumes of data involved.

3.3 Policy Issues. Among the key policy issues related to graphics and text standardization which are emerging from the CALS study are the following:

a. Existing policies do not support a minimum set of standards for digital acquisition and transfer of technical data for weapon system logistics support to (and among) government users.

b. Near term and long range plans to achieve interoperability and interchangeability of digital weapon support technical data do not exist.

c. A standardized set of data elements for maintaining technical information electronically during the weapon system acquisition process does not exist.

d. Existing DoD plans for providing long-haul and area data communications services (the Defense Data Network) may not support the volume of CALS data envisioned.

4. EVALUATION AND CURRENT STATUS. The scope of graphics and text standardization efforts was briefly surveyed in Section 2. This section describes the evolution of those standards, and identifies for further discussion those which appear to have the greatest potential for satisfying the DoD objectives listed in Section 3. These are placed within the context of current usage within government and industry, as well as current expectations as to their future utility.

4.1 Development and Status. Graphics and text standardization has lagged the computer technology developed to utilize those capabilities. In an era of explosive technology growth in these areas, a lag of even two or three years means that a standard can become out of date before it can be applied. This point is critical because few of the existing or proposed standards are entirely adequate to the task they are designed to address. IGES, for example, is widely touted as the only practical approach to exchanging CAD/CAM data and is widely used for that purpose. Yet IGES is just as widely criticized for being incomplete, difficult and costly to use, and sometimes untrustworthy even for the transmission of those parts of CAD/CAM data which it does address. For more sophisticated applications of graphics and text (such as CAD/CAM), only a proprietary system interfaced with the same proprietary system implemented on virtually the

same hardware configuration offers reasonable assurance of completely accurate data exchange. Yet it is in CAD/CAM applications that a proprietary system is least likely to be adopted as a de facto standard by a large number of users, as has occurred (for example) with CORE. Although this suggests a nearly insoluble problem, in fact, DoD can make a significant contribution to the development, validation, and application of these standards. This paper proposes a course of action through which DoD can judiciously apply its resources to reduce the standardization lag time and facilitate the implementation of those standards that best meet DoD's needs.

4.1.1 CAD/CAM Standards. As noted, IGES is the only presently available CAD/CAM standard, albeit an incomplete and controversial one. PHIGS, which is in essence an evolutionary development of graphics standards for delivery/presentation systems, has some potential for becoming a "first cut" CAD/CAM graphics language standard but is still too far from completion to evaluate. Even when complete, PHIGS will be only a graphics standard, and still will not address full product definition, which is the key to establishing the CAD/CAM interface within a Computer Integrated Manufacturing (CIM) environment. Meanwhile, the major CAD/CAM vendors would each be happy to see their system emerge as a de facto standard. This is unlikely to occur, although ongoing proprietary and non-proprietary work in electronics and electrical applications may provide the foundations for future Versions of IGES, just as Boeing's CAD/CAM Integrated Information Network (CIIN) provided major input to IGES Version 1.0.

4.1.1.1 IGES. IGES originated in the Air Force's Integrated Computer Aided Manufacturing (ICAM) program. Using development funding provided by the Military Services and NASA, the National Bureau of Standards (NBS) and several industry representatives developed the initial version of the standard during the fall of 1979. This initial version was based in large part of Boeing's CIIN format, with enhancements from General Electric's Neutral Data Base work and others, and was specifically oriented toward mechanical applications that dominated existing CAD implementations within the aerospace industry; it was published as IGES Version 1.0 in January 1980. In May 1980, ANSI began incorporating IGES into a draft standard on Digital Representation for Communication of Product Definition Data Y14.26M). Even before the draft was released for public comment in October 1980, three of the major CAD/CAM vendors announced initial IGES translators. However, limited intersystem transfer of IGES data was not publicly demonstrated until December 1981. By then, the ANSI standard containing IGES Version 1.3 had been published (September 1981), and shortly afterward DoD published an Acceptance Notice for IGES (January 1982). Version 2.0 of IGES was released by the IGES committee in July 1982, and subsequently proposed for incorporation into the Y14.26M ANSI standard, although this work was never completed. Version

2.0 and Version 3.0 (formerly called Version 2.1, scheduled for release in December 1984 or early 1985) contain a number of technical enhancements which are mostly upward compatible from earlier versions, as well as extensions into finite element modeling and printed wiring board data. While development of Version 2.1 continues, efforts to produce the next version of IGES (originally labeled as Version 3.0) with extensions into solid geometry and actual product definition are also underway. This "next generation" IGES will be a key step in linking CAD and CAM into a true CIM environment, based on exchange of product definition data. When "Version 3.0" (retitled as the "Product Definition Exchange Standard") is available in late 1985 or early 1986, it will also incorporate some of the features of IGES's principal European competitors, and (hopefully) provide a basis for ISO acceptance of IGES. For example, the French SET exchange standard provides a more efficient file structure than IGES, an important factor for high volume electronic transmission of product definition or drawing data. This is one of the major areas being addressed by the Product Definition Data Interface project discussed in Sections 5.1.2. and 5.1.3. A number of companies and committees are working on other IGES enhancements. These include not only finite element modeling within mechanical applications, but also electrical, electronic, hydraulic, architectural, and other extensions. Over a dozen CAD/CAM vendors have demonstrated IGES translators, or provided test data, and a score of others are publicly committed to development of translators. Hence, American CAD/CAM manufacturers and users have largely accepted IGES data standardization. However, a recent Air Force ICAM study confirmed earlier findings that existing IGES translators exhibit inadequacies which still restrict such use.

4.1.1.2 PHIGS. One reason why CORE was not immediately accepted by ANSI in 1977 was the desire to create a "Super CORE" standard. Once GKS had been accepted as a graphics standardization working item by the International Standards Organization, ANSI's hoped-for Super CORE won redefinition as the proposed "next step up" in graphics standards. The result will be PHIGS, which is presently a set of objectives, issues, and proposed approaches incorporated in a draft standard that will be available for public review in mid 1985. Then potential users will be able to determine if PHIGS will provide even a preliminary CAD/CAM graphics language standard. PHIGS is presently intended to be a major upgrade of GKS offering three-dimensional (vice GKS's two-dimensional) displays and rotation capability, additional levels of hierarchical segmentation (called structures), and the faster response time needed by dynamic CAD/CAM systems, all within reduced program overhead. PHIGS is being specifically designed for highly interactive display and manipulation of large graphic data bases stored both on-line (i.e., RAM disks) and off-line. Hence, while GKS is a stepping-off point for PHIGS, PHIGS is deliberately not "GKS plus". Some GKS features were

excluded because it was perceived that they would compromise the efficiency of PHIGS. Other features are necessarily different because PHIGS is attempting to accomplish more than GKS. But PHIGS maintains many basic GKS concepts, and it is expected that a GKS shell can be written around a PHIGS kernel for GKS users. Of course, the only present implementations of PHIGS are experimental, such as that underway at Rensselaer Polytechnic Institute.

4.1.2. Delivery/Presentation (Authoring System) Standards. Automated authoring systems represent only one variety of delivery and presentation system. Others include graphic arts for television or advertising, mapping and chartmaking, photographic conversion/display, etc. These all have defense applications of greater or lesser significance, and they all share a common interest in text and graphics standardization. Even though the emphasis changes from application to application, there is no form of delivery or presentation system which is totally disinterested in one particular type of standard. Hence, the standards addressed here as "authoring system standards" have usually been developed to support a wider audience, and frequently have more extensive capability than an authoring system per se requires. For example, only time will tell whether PHIGS will emerge as a high-level standard for authoring systems, or a low-level standard for CAD/CAM systems. Similarly, GenCode presently provides more extensive capability for text markup than is generally required for military technical publications, yet it is the obvious preferred standard for that application at this point in time. Developments such as ISO's Office Document Architecture are not yet ready for use.

4.1.2.1 Authoring System Text Standards. GenCode and SGML are gaining widespread acceptance, both in the United States and in Europe. But - especially at the low cost, word processor end of the scale of automated authoring systems - GenCode and SGML still face stiff competition from proprietary text processing systems whose manufacturers and owner/users have a vested interest in not adopting any standard text language. DIF responds to this problem by providing a common interchange format for text and for a common subset of text processor control codes. However, DIF can be perceived as a temporary solution, the requirement for which can be largely bounded by the life of existing equipment investments.

4.1.2.1.1 SGML. Discussion of standardized generic text markup for typesetting and composition dates from the late 1960's and early 1970's, with active support from the Association of American Publishers, the Graphic Communications Association (GCA), some federal agencies such as the Internal Revenue Service, and various contractors. Generic text markup can be done in a variety of ways, and the SGML/GenCode standard is only one of them. The Association of American Publishers has a generic text markup system developed as part of its Electronic Manuscript Project; proprietary systems such as IBM's GenCode-like GML are

in use; ISO, ANSI, and industry associations have seen a variety of generic tagging approaches put into experimental or operational use. During the 1970's, GCA proceeded with development of GenCode, which forms the core of the SGML standard drafted by ANSI and ISO during the 1980's. The standard adds to this GenCode core a proposed text programming language through which the independent SGML/GenCode document markup language could be implemented, along with entry/edit and format composition applications, and GKS binding. Translator development for specific hardware applications is not addressed because it is not considered to be a major implementation problem. The SGML draft was published by ISO in June 1983, and at the same time GCA published GenCode as a stand-alone, "trial use" standard. The GenCode portion of SGML was accepted by DoD in August 1983, and is presently in use not only within DoD, but other federal agencies as well. GenCode's increasing acceptance and use in industry, especially the mass market publishing community, makes it and SGML the "no contest" standards of choice for text processing. The complete SGML will be adopted as a formal standard within the next several months. Meanwhile, GenCode Change 1 is being processed for DoD acceptance. The defense industry lags in implementation of GenCode, but only because of fewer direct ties to the "publishing industry," in which the document itself is an end product. There is no significant opposition to GenCode, although the effort by some equipment manufacturers to gain market share for their own proprietary text processing systems continues. Eventually, SGML may be subsumed by ISO's Office Document Architecture, but that lies several years in the future.

4.1.2.1.2 DIF. DIF provides a vehicle whereby those proprietary text processing systems can satisfy the requirement to exchange data, without themselves employing a standard language. DIF was developed by the National Bureau of Standards at the request of the Navy, and published by them in early 1984. It is presently considered to be an "interim" Navy standard pending completion of staff coordination. DIF has broader applications as well; for example, non-text processing applications accessible through a proprietary word processing system can generate DIF-formatted output files, which can then be input to other DIF-compatible text processing systems for composition. Eventually, SGML will also provide this same capability, as it already plans to do with GKS graphics, as well as with DIF-formatted text files. Once this flexibility is fully incorporated into SGML, DIF's lifespan will be largely measurable by that of the proprietary systems then in use.

4.1.2.2 Authoring System Graphics Standards. There is no "authoring system graphics standard;" there are several delivery/presentation graphics standards that can be used for illustration of technical documentation, plus the usual host of proprietary systems. There is serious controversy among advocates of the various approaches. Among the five contenders for "the" graphics language standard (CORE, PMIG, GKS, VDI, and PHIGS), two may be set aside. PMIG, as noted in Section 2.2.1.2, is a side channel

from the mainstream, not really applicable to current and future automated authoring. PHIGS is a standard yet to be developed and applied; pragmatically, whatever attention or support it receives should come from its potential application to CAD/CAM/CAE, at least until the lingering debate over CORE and GKS is settled. (While VDI can be used independently for graphics programming, it very rarely will be. Graphics programming will be done using CORE or GKS (or PHIGS), which will then access VDI device drivers for maximum hardware independence.) Thus, the three principal graphics language standards of interest are CORE, GKS, and VDI. And, of course, there are also the two contenders for data storage and transfer - VDM and NAPLPS.

4.1.2.2.1 CORE. In part, the graphics standards controversy is a function of advocacy politics, sunk cost investments, and even nationalism. But there are technical advantages and disadvantages as well. CORE, the oldest of the proposed graphics language standards, is well structured and conceptually simpler than GKS. It also supports a three-dimensional capability, which GKS lacks. Hence, it offers the delivery/presentation community some significant advantages, especially for annimated real time or interactive visual arts. CORE was developed between 1976 and 1979 by a subgroup of the American Association for Computing Machinery, after a five-year period during which there had been much discussion of, but only limited progress toward development of a graphics language standard. Because it was the first real graphics standard, and because it was both comprehensive and simple to use, it quickly gained wide user support. Automated authoring system users may be attracted by its simplicity, and its three-dimensional capability offers potential advantages in some areas, such as training material and maintenance aids. Even though it is only a de facto standard, it has stood the test of time since its initial publication. However, it does have some technical limitations, such as the lack of standard language bindings. CORE was developed around functional concepts that included the idea that internal structure and application are more important than syntax and calling sequence details. CORE was submitted for ANSI approval, but was held up for refinements, during the course of which it was overrun by GKS. Some see the CORE standard as being "underspecified" as compared to GKS, creating conformance problems. However, this may simply reflect the greater attention paid to GKS since its emergence. CORE still has a community of loyal, even diehard supporters. It is used in a number of application programs and remains a serious graphics standard candidate, at least for some users.

4.1.2.2.2 GKS. However, the Graphics Kernel System is the current leading candidate for an overall graphics language standard. GKS's explicit links to SGML were noted in Section 4.1.2.1.1. Standard bindings to other programming languages (FORTRAN initially, followed by Ada, Pascal, PL/1, and even Cobol) are or will be available, in contrast to CORE. Other GKS advantages include workstation definition (a nuisance to those very rare single input/output device users, but a small step

toward device independence for multi-device users), multiple viewports for more throughput efficiency, better attribute management, and a variety of other technical characteristics which make it more complete and detailed than CORE. Supporters also view GKS as more highly specified, making conformance to the standard easier. This is because GKS is several years more current than CORE, having continued through a number of versions at the International Standards Organization level while CORE remained at the ANSI subgroup level. At the same time as CORE was being developed in the United States, West Germany was pursuing a standardization effort that became GKS. From its West German originators, who based their work in part on the 1977 first draft of CORE, GKS went to ISO, which in turn proposed its acceptance by ANSI. In mid-1982, the ANSI subcommittee that had been "refining" CORE ("Super CORE") voted instead to support GKS. As much as anything else, it was this action which created the CORE/GKS political controversy. GKS is now in the final stages of approval at both ANSI and ISO levels. Although GKS is more advanced than CORE, it is also more complex to learn and use, and requires greater hardware capability. Nonetheless, GKS now has broader industry backing than CORE, and is widely seen as the preferred vehicle for most of the graphics applications necessary in automated authoring. Its principal deficiency, two-dimensional vice three-dimensional capability, may be overcome by a PHIGS-like extension that is currently under development and will probably be completed before PHIGS is approved.

4.1.2.2.3 VDI (CGI). GKS is one step closer to device independence than CORE. However, GKS is still basically a device dependent application graphics language. VDI, the first draft of which is still being developed for release in 1985, is a further major step in the direction of device independence. Unfortunately, despite strong industry support, even the experts aren't in complete agreement about what VDI is, and what it isn't. Some portray it as a competitor to GKS, although most other analysts recognize it as a complement to both GKS and CORE. In part, this may be due to the fact that the form of the VDI command set, which will be substantially less sophisticated than that of GKS, isn't fully settled. But in addition, VDI commands can be applied directly, or they can be manipulated by the GKS, CORE, or proprietary graphics command set used in the application program. This latter technique is the intended method for using the much simpler set of VDI command primitives to provide the maximum amount of "device independent" capability. Even at its best, VDI will not be totally device independent, but it will represent a major advance over GKS in this respect. Device dependent interfaces for VDI will be smaller and simpler to write than for GKS, and may be incorporated in hardware connectors at some point in time. Once the standard is fully settled - several years from now - most graphics-related computer equipment will incorporate VDI firmware. This will interface with application programs, which will generally use CORE, GKS, or even PHIGS software for graphics generation because of their much greater capability. VDI's developers see this standard as a vital complement to these

or any other proprietary graphics language standards, since VDI alone can only satisfy very simple graphics programming tasks. What experience (and time) alone will determine is the extent to which programmers will choose to use CORE/GKS/PHIGS to drive VDI, as intended, vice driving VDI directly from the application program.

4.1.2.2.4 VDM (CGM). VDM is presently a draft standard, for which public review and ANSI approval is expected in mid-1985. Originally conceived as the device independent data storage/transfer counterpart to VDI, it may be finding itself overtaken by events even before the public review and re-drafting process for the VDM standard is complete. There is a degree of functional overlap between VDM and NAPLPS, and it is unclear at this time whether both will survive. If not, then VDM may be the candidate more likely to be discarded, for although some of its features are more complete, it has a lesser range of functions and less popular support. VDM defines a VDI-compatible and GKS-compatible, compact, neutral file format for two-dimensional graphics image storage. VDM is a "picture capture" standard. On the other hand, the metafile included as part of the GKS standard as a stop-gap pending VDM's availability provides an audit trail of picture changes by capturing successive GKS calls. Text with a broad range of formatting attributes can be stored in concert VDM graphics, but VDM is neither designed nor intended for text file handling. VDM's strength is its developmental association with the principal graphics standards; its weakness is its narrow scope. Its primary application may be for permanent or temporary file storage in stand-alone systems, or for archiving of data where on-line communication is not a major factor. Here the advantages of neutral file format would outweigh the shortcomings of VDM's narrow scope.

4.1.2.2.5 NAPLPS. The North American Presentation Level Protocol Syntax is the dominant American example of a worldwide technology collectively known as videotex, or videotext. (Within the videotex industry, a technical distinction is drawn between two-way videotex communication and one-way teletex communication; here, the term videotex is used generically to represent both one-way and two-way data transmission.) The original British version, called Prestel, went into commercial operation in 1979, followed shortly afterward by separate French, German/Dutch, Canadian, and Japanese formats. NAPLPS is an outgrowth of the Canadian Telidon system, via an intermediate AT&T product called simply the Presentation Level Protocol. It has deliberately sought Prestel compatibility by defining low/medium resolution Prestel mosaics as one of its optional character sets. NAPLPS also has some characteristics of Antiope (the French system), as indeed all the national systems have some technical similarities. Unfortunately, there are also significant differences among the systems, and the British - whose Prestel technology (extended to accommodate French system requirements) has been generally endorsed as the European CEPT, or Council of European Postal Telegraph, standard - have been reluctant to accept NAPLPS, which is now an ANSI and Canadian standard. Prestel has been introduced in the United States, but has only limited support. The

cost of translators for either Prestel or NAPLPS is still a barrier to widespread commercial use, and simpler ASCII-based videotex-like systems such as Dow Jones, Compuserve, and the Source lead the American market. As translator costs decrease, and marketing efforts attract more potential users, NAPLPS applications will expand, replacing or upgrading these systems. For one-way teletex, the British Prestel technology and a NAPLPS-compatible North American Broadcast Teletext Specification (NABTS) are competing for de facto acceptance, with NABTS projected as the successful candidate. Because NAPLPS is an approved standard, based on international proprietary and non-proprietary developmental effort extending back ten years or more, it already has sufficient usage experience to prove its technical capability for handling both text and graphics exchange, even though the number of NAPLPS implementations is still small. But NAPLPS was developed for broadcast communication applications (ie, presentation of graphics with incorporated text). Its long-term utility for file transfer of automated authoring system files (ie, transmission of text with incorporated graphics) is unclear, although there is no inherent reason why NAPLPS, with its ASCII text subset, should be unsuitable to this task. Some observers see NAPLPS as a nearly universal data exchange standard; others see it as a "device dependent," special purpose "version" of VDI; while others view NAPLPS as a standard with no role whatever in the issues addressed by this paper. However, use of the Antiope system as a vehicle for video distribution of the French telephone directory suggests that NAPLPS may have a bigger role to play in distribution of technical manuals than the graphics are community recognizes. What may be of greater concern, however, is the long-term evolution of NAPLPS. A proposed world standard is being developed, based on the best features of the European and American standards, as well as the Japanese system, which accommodates Kanji characters by a raster, or alphaphotographic approach.

4.2 <u>System Integration</u>. What has been addressed thus far are the variety of different principal standardization efforts related to graphics and text standards. In some cases, linkages among these standards have been noted - for example, the developmental history of GKS based in part on CORE, the planned binding between SGML and GKS, or the parallel development of VDI and VDM. Fundamentally, however, the interfaces among these standards have yet to be addressed by industry, leaving unanswered questions about the ability of existing standards to fully satisfy DoD objectives. The interface between DIF-formatted text files and GenCode/SGML, via a translator, needs to be developed. The IGES/VDM/GKS interface, via a set of translators, is just beginning to be explored, and even the intended linkage between VDM and GKS is conceptual rather than physical. Even when these interfaces are defined, their initial implementations are likely to be cumbersome at best, and additional conceptual effort and practical experimentation will be needed to introduce both design efficiency and ease of use. Of course, these problems are complicated by the fluid character of the standards themselves. Major attention

will be needed to achieve vertical integration of those individual standards which hold the greatest potential for satisfying DoD objectives.

4.3 Implementation Efforts. Further complications are introduced as users attempt to implement the individual standards, filling in gaps in capability with system-unique logic. For example, GKS offers graphics program and data portability between GKS-based systems, but does not assure data portability to a non-GKS system because the VDI/VDM standards are still under development, while a GKS-compatible system with a proprietary three-dimensional extension would preclude even program portability. Despite DoD preference for adoption and use of industry (non-government) standards, some form of interim DoD standards or specifications may be needed if near term data/program exchange among the Military Departments and defense contractors is to be achieved. Individual Service actions may introduce additional incompatibility, particularly for interservice data exchange. For example, NAVSEA's recent action in adopting IGES Version 2.0 for CAD/CAM data exchange establishes a clear policy to be followed for ship acquisition programs, but leaves several questions about data compatibility unanswered. The NAVSEA Instruction 5230.8 provides a phased implementation schedule (June 1984-December 1985) for IGES Version 2.0 entities to be used by prime contractors in delivering CAD/CAM data to the Navy, encourages but does not require use of IGES by subcontractors unless dealing directly with NAVSEA, and recognizes but does not address current IGES limitations. These problems, along with that of the government to effectively validate, store/retrieve, and utilize this data, should be addressed before DoD commits itself to a major initiative with respect to use of IGES, or any other graphics/text standard.

4.4. Conclusions. All of the standards identified in this paper have limitations of some form, even NAPLPS and SGML, which are the most complete. SGML (GenCode) and IGES are widely accepted as the standards of choice in their respective areas. Questions and some controversy exist concerning the choice between GKS and CORE, and between VDM and NAPLPS, although GKS and NAPLPS respectively appear to offer the greater benefits, as well as having the greater support. VDI will provide important benefits, and may affect both the GKS/CORE and VDM/NAPLPS issues. PHIGS may represent a significant enhancement over both GKS and CORE, but its development is still too formative to warrant more than very supportive interest. Only PMIG, which has little attraction for automated authoring of technical documentation, and DIF, which is coming into use in the Navy, can be set aside. Despite its recent adoption by the Navy, DIF represents an interim solution to a current (albeit, very real) problem, not a long term mechanism for meeting DoD objectives. All standards require validation of both the standard itself and the various implementations of the standard. The more sophisticated and elaborate the standard, such as IGES, the greater the validation problem.

5. CONTENT AND APPLICATION OF STANDARDS. This section addresses the major characteristics, content, advantages, and limitations of each of the applicable standards surveyed in the preceeding sections. Major emphasis is placed on IGES, which not only offers the greatest opportunity to contribute to the satisfaction of DoD text/graphics standard objectives, but where major problems and corrective initiatives are needed and underway.

5.1 IGES Content. The IGES standard describes both the form for communicating partial product definition information, and the type of information to be communicated. The form consists of file format and structure -- record size, data types, file section definitions, field descriptions and sizes (where applicable), coding structure, etc. The unit of information which IGES communicates is termed the "entity." The manner through which entities are hierarchically grouped or associated with one another defines the product which the IGES file specifies. Although the basic IGES file format is relatively primitive and rigid (eighty character records, ordered sections for file definition and locator coding), considerable flexibility and expansion potential is offered by liberal use of free formatting for individual entities, and use of pointers for referencing. Each entity consists of a fixed-format directory entry, and a free or semi-free format parameter data entry, which the directory entry references. IGES entities are grouped within major categories that are each part of the overall product definition. These categories - geometry, annotation, and structural relationships - are not professed to be exhaustive. Rather, like IGES entities themselves, they are intended to be initial building blocks to an overall product definition, the complete content of which has not yet been defined. Nor are the entities exhaustive within a category, or exhaustive across all products. For example, IGES entities presently can represent two- and three-dimensional wire frame geometry, but not solids. What is important is that the IGES standard is generally extensible, both in form and content, so that future versions (including the Product Definition Exchange Standard, or PDES, with its major product definition enhancements) should be largely upward compatible, imposing minimum changes on existing implementations and (hopefully) translators. Although it is possible that future elaborations/revisions of product definition content may require that IGES be entirely discarded, this possibility presently appears unlikely.

5.1.1 Product Definition Categories. As presently available, IGES supports significant portions of computer aided design/engineering capability for mechanical applications. Its entities are grouped into categories called geometry, annotation, and structure. The geometry category provides a pictorial description of the product's shape and topology. Simple geometric entities such as lines and conics, surface entities such as the tabulated cylinder, and combinations of these entities linked through supporting structural entities make up this category. The annotation category clarifies the product's geometry through entities that provide dimensions and tolerances, notes, labels,

centerlines, etc. Most important, however, are entities in the structure category, through which entities in the geometry and annotation categories are bound together to form the complete product. Structural entities specify logical relationships and attributes. Attributes include properties, drawing viewports, line and text font definitions. Logical relationships include associativity among other entities or classes of entities, and subfigures which define complete subordinate products occurring one or many times within the overall product definition. A macro entity is also provided to build new entities using other basic IGES entities or macros.

5.1.2 Product Definition Data Interface. From the beginning, IGES has been described as a product definition standard, although its current title - Graphics Exchange - is a more accurate description of its current actual content. The potential importance of IGES as a product definition standard lies in the ability not merely to exchange IGES-formatted data among CAD systems, but also in the potential to pass IGES-formatted data from CAD to automated manufacturing planning processes. Although this can be done now, the IGES data by itself is still inadequate, because it is both incomplete and improperly structured for ADP processing. Traditionally, manufacturing planning has been based on data read from engineering drawings (eg, part and reference geometry), data interpreted from the engineering drawings (eg, part features, such as flanges and cutouts), separate data listings (eg, bills of material), and various automated and non-automated process planning tools for cost, schedule, other administrative control requirements, tool design, NC programming, etc. In its present state of development, IGES provides for automation of a sophisticated engineering drawing; however, much of the non-geometric data on the drawing is passed using IGES annotation entities that digitize what is more properly "human readable" text than machine-readable data. The Air Force's Product Definition Data Interface (PDDI) project is an effort to prototype the solution to this deficiency, leading to expanded content and applicability for an IGES which is much more of a product definition standard than it is at present, and hence much more valuable for satisfying CALS objectives.

5.1.3 PDDI Product Scope. In line with the remainder of the Integrated Computer Aided Manufacturing (ICAM) program from which it originated, the PDDI project is looking at a class of products which can be manufactured in an automated sheet metal shop. These products are mechanical applications from the F-18 wing leading edge extension and trailing edge flap, toward which the structure of IGES is presently oriented, and include sheet metal and composite ribs, plus sheet metal and composite skins. A turned part created earlier for the CAM-I Geometric Modeling Project is also being used. Hence, the PDDI project will not create a complete product definition for all classes of products, nor for all manufacturing processes. However, when complete in mid-1985, the PDDI effort will have defined and demonstrated a standard automated format for a significant subset of the product

definition data required for original manufacture, and for later re-manufacture or modification. This format, expressed as a new class of entities, will be incorporated in PDES when it is released for public comment in December 1985 or early 1986. Further, the PDDI definition is being developed in a form that will facilitate its extension to other product classes and manufacturing processes. That is, a clear distinction is being developed between the logical layer of PDDI, in which the entities themselves are defined, and the physical layer, in which the file format and data structure of the entities are defined.

5.1.4 Product Definition Deficiencies. As noted, a complete product definition, encompassing all the data needed for design, manufacturing, provisioning, and operational support for all products, will still have to be developed. IGES as it currently exists has been designed to accommodate that portion of the product design which could be most fully and easily extracted from existing computer aided design systems. Even this it does incompletely. Versions 2.0 and 3.0 (the old Version 2.1) improve and extend IGES Version 1.0's treatment of mechanical application design, and add finite element modeling and preliminary definition of electronics printed wiring boards. The PDDI state of the art survey of available and emerging CAD product definition technologies for mechanical applications found that definition and relationships of part features, as well as constructive dimensions and tolerances, are not yet addressed. Most non-shape related data (tolerances, material, finish/process specifications, drawing notes, part control) is addressed, but not well integrated with part geometry. IGES reflects these CAD deficiencies. IGES Version 2.0 is still limited to wire frame and surface designs; it does not encompass solid (volume) modeling for mechanical applications, and lacks essential features needed for the new extensions, such as schematic drawing transfer for printed wiring boards. Preliminary work has been done in these areas, and PDES will contain further improvements together with the PDDI proposals. However, the PPES standard is basically being built around two major extensions to IGES: the PDDI project, and CAM-I's Experimental Solids Proposal that deals with both boundary representation and constructive solid geometry. Areas such as cabling and harness specifications, integrated circuits and printed circuit boards, architectural engineering, plant and facility design, and manufacturing processes require much more work. Proprietary CAD systems are far ahead of IGES in these areas. However, even for mechanical applications, there are some technologies (such as constructive dimensioning and tolerancing) which are still in the preliminary development stage. Others (such as homogeneous parametric forms for system-internal geometry representation) are steadily evolving, so that current techniques may become obsolete as more efficient approaches are developed. Transmission of other "product definition"-related data, such as R&M parameters or provisioning data (or any MIL-STD-1388-2A data), has until recently been only a suggestion for future consideration. (Based on discussion with the PDDI contractor, it appears possible to initiate a PDDI extension that

would incorporate some logistics data, such as provisioning technical data as part of the bill of materials definition, in PDES.) This means that completely incorporating such factors in IGES could be three to four years away, even with the DoD funding increases that could expedite development.

5.1.5 <u>IGES Translators</u>. Because it is not a CAD language, IGES as a stand-alone product is useless; its utility depends on the availability and quality of translators from each unique CAD system to IGES (pre-processors) and from IGES to each unique CAD system (post-processors). These "indirect" translators serve the dual purpose of reducing the magnitude (time and resource invest- investment) of the translator development burden, and preserving the security of proprietary CAD/CAM software. However, a one-to-one mapping between IGES entities and those of the unique CAD/CAM software is extremely difficult, and the decision rules for dealing with mapping options (one to many, one to null, many to one, many to null) are critical. Even with one-to-one mapping, the translation can cause loss of functionality, so that the eventual system-unique output entity cannot be used or manipulated in the same way as the original input entity. Hence the significance of translator validation. Over a dozen CAD/CAM vendors, including most of the major manufacturers, have demonstrated IGES translators. However, a recent study undertaken as part of the PDDI project confirmed findings by others that IGES translators are less adequate than expected. Problems include quality of translation, subsetting of the IGES standard or variations among versions of IGES, and operational or conceptual differences between sending and receiving CAD systems. The tests were themselves less than complete; the PDDI survey, for example, was largely based on the original IGES Version 1.0, not the more current Version 2.0, that has been available in draft for about two years, or the new Version 3.0, that is nearing technical completion. Consequently, much work remains to assure that IGES - even to the extent to which it is presently developed - can be confidently used for CAD/CAM weapon system data exchange, especially where a significant DoD application involves archiving data for post production support years after the original design team has been disbanded. Again, funding is a significant constraint, for development of test data and physical review of translated files are time consuming and extremely labor intensive.

5.1.6 <u>IGES Data Requirements</u>. Although DoD objectives for transmission and storage of CAD/CAM data can be best satisfied by availability of a complete IGES standard (including logistics data) and fully validated translators for at least the major vendor systems, it remains unclear what subset of this ambitious goal is sufficient for the near term. The same PDDI study which questioned the adequacy of IGES translators, found that IGES provided largely adequate representation of the class of CAD drawings that were tested. However, this only touches on potential IGES requirements for drawing repositories, configuration management, post production support, etc., as they apply to inte-

grated circuits and other product classes not yet incorporated in IGES.

5.2 Graphics Kernel System. GKS provides a set of 185 different functions, some of which are complex, even though they are very powerful. For example, coordinate transformation for output to a display device can be a four-step process, sometimes requiring the programmer to choose between trial-and-error and a pocket calculator for translating application coordinates (the computed or observed values to be plotted) to world coordinates (the Cartesian scale that may or may not be the same as the application coordinates), for which an application program routine may need to be developed, to normalized device coordinates (a part of the 1x1 GKS unit screen onto which a part of the world coordinate display is mapped), for which the programmer must define both SET WINDOW and SET VIEWPORT limits so that GKS's normalization transform routine can accomplish the actual translation, to physical device coordinates (the physical resolution of the hardware display device), which the hardware-dependent graphics device driver handles automatically once the programmer has provided composition layout for his graphic art, tables, and text. GKS's solution to the complexity problem - the opposite of that taken by the designers of Ada - is to encourage language subsets. By discouraging subsets, Ada delayed implementation but facilitated full program transportability when implementation occurred; by encouraging subsets, GKS has facilitated (both eased and speeded) implementation, but decreased transportability potential. Moreover, even the "M" (minimum-level) subset requires so much in-memory storage that few 8-bit microprocessor applications are likely. On the other hand, the complete GKS function set (level 2b, or the more operating system-dependent level 2c) offers extensive capability. A particulary useful feature - though also an impediment to transportability - is its generalized drawing primitive, which allows escape from GKS to the proprietary graphics commands offered by the host software system. For example, GKS has no "CIRCLE" command. A circle can be drawn in GKS either by loading the circle point values into one or more arrays and then using a GKS "POLYLINE" command, or more simply by using a generalized drawing primitive that employs a host software "CIRCLE" command to automatically convert center coordinate and radius values into the required boundary points. (A "registry" of generalized drawing primitives will partially standardize these calls, enhancing transportability to those systems that choose to support the registered calls.) Another valuable GKS feature is a strong set of inquiry function to check and return device status for controlling the application program.

5.2.1 Workstation and Bundling Control. Although GKS is not device independent in the same way that VDI will be, much work has gone into defining powerful, albeit sometimes complicated, techniques that make GKS programs highly independent from the form of the physical device used for output. One technique used to accomplish this is through the conceptual abstract of a "workstation," which programmatically defines the characteristics of

one or more output devices to which GKS graphics can be driven. For example, in a simple monochrome system with a terminal and plotter, workstation one might be defined to generate white lines on a black background (the terminal), and workstation two to generate black lines on a white background (the plotter). The same POLYLINE command would drive each workstation according to its predefined characteristics. A more sophisticated program would use a workstation bundle table to set color index, line type and width, and other attributes for each physical output device associated with the particular system on which the GKS graphics program was developed. When that program is moved to another system, the workstation definitions could be easily changed without disturbing the remainder of the program. Attributes which are common to all workstations can still be set individually (ie, unbundled).

5.2.2 Segmentation. One of GKS's most powerful capabilities is segmentation, which provides a graphics tool similar to a programming language subroutine. This allows graphic images to be built up from simpler GKS primitives and then manipulated by single transformation commands which rotate, highlight, or color the entire segment. This capability is important for any application, including technical document illustration, but offers particular potential for terminal display of training material or maintenance aids. However, GKS does not allow nesting (or hierarchies) of segments, as will be possible with PHIGS structures.

5.2.3 GKS Deficiencies. In the confrontational warfare between GKS and CORE, GKS has principally been criticized for its lack of three-dimensional capability and its complexity. Whether the former represents a critical deficiency for CALS applications (such as interactive training) is unclear. Complexity does represent a problem (which GKS supporters minimize), particularly when subsetting is encouraged, but in return offers functional flexibility that has made GKS the preferred standard among industry users of graphics. Once bindings to SGML and a range of programming languages are in place, GKS applications will proliferate. A pre-PHIGS three-dimensional extension to GKS is being developed, and device independence will be enhanced through interfaces with VDI and VDM. GKS provides its own metafile construct, and the input/output functions to access such a file, but not a standardized data storage format. Other technical shortcomings (such as a cell array primitive for storing raster "pixelated image" graphics, that lacks an independent attribute list and multiple image capability, or multiple sets of lookup tables) can be corrected by future extensions.

5.3 CORE. Despite the comparison between complex GKS and simple CORE, these two graphics standards actually have much in common. CORE is the earlier standard, and its published draft in 1977 provided major input to the construction of GKS. Although there are other technical variations, the principal differences between CORE and GKS arise from the deliberate effort to increase the flexibility of GKS graphics. CORE lacks the

concepts of workstations, attribute bundling, and multiple viewports. Also, CORE uses a "pen movement" concept and relative positioning, in which the results of output primitives (commands) may depend on the results of previous commands. GKS, on the other hand, is designed so that each command can be independent of all preceeding commands. Lack of standard bindings, such as GKS does/will offer, is an inhibitor to usage of CORE, although not an absolute constraint; there are numerous CORE or CORE-like applications which have built up a small but intensely loyal community of support for this de facto standard. CORE also faces transportability problems because of the workstation/bundling deficiency, and partly because - like GKS - CORE encourages subsetting.

5.3.1 Three-Dimensionality. In the final analysis, it is the issue of three-dimensionality that maintains CORE as a viable potential candidate for an industry-wide graphics standard, and as a potential satisfier of CALS objectives. Pending development of a standard three-dimensional extension, GKS can simulate three dimensions in the same manner that an artist simulates three dimensions on a flat surface, but only by adding commands to the program that fix the viewing perspective. This is because GKS was designed to be only a two-dimensional graphics standard. On the other hand, CORE offers a true three-dimensional capability. With CORE, the graphic can be generated in a three-dimensional volume that is integrated with the viewing transformation, and mapped into a three-dimensional normalized device space. This can be displayed directly on a device that supports three dimensions, or transformed again for output on a two-dimensional display device. This final transformation can either eliminate the third axis entirely, or angle it, as a flat surface artist would do. Although CORE's three-dimensionality may offer some advantages for illustration of technical publications (particularly in an integrated system where graphics are built from a three-dimensional IGES source data file), it appears that for most technical illustration purposes, GKS's greater flexibility and slightly greater device independence offers more functional benefit than CORE. However, this may not be true in the case of interactive training material and maintenance aids displayed on-screen. Here there are obvious advantages to three-dimensionality, particularly if the viewing angle and perspective can be user-controlled. For this reason, CORE cannot simply be dismissed from consideration, at least until a non-proprietary three-dimensional extension to GKS is available.

5.4 Programmer's Hierarchical Interactive Graphics Standard. The development of PHIGS, for which an initial draft is now being completed, is intended to remedy the principal shortcomings of both CORE and GKS. It is too soon to determine whether it will be successful in meeting this objective, or in supporting CAD/CAM graphics requirements. PHIGS' developers address, but do not stress, its potential CAD/CAM role, and are discretely cautious

about the extent to which PHIGS will subsume GKS applications outside the CAD/CAM world. PHIGS will offer three-dimensionality, and a multi-level segmentation (structures) hierarchy, with lower memory overhead and faster response time. Although PHIGS represents an evolutionary advance in graphics languages, it will not be fully upward compatible with either CORE or GKS. PHIGS structures consist of an ordered list of elements, in which attributes are applied to graphics primitives as the (nested) hierarchy is traversed. On the other hand, in GKS' single-level segments the attributes are applied as the primitive is initially defined, and the segment list itself is an unordered collection. The transformation pipeline - from a modeling coordinate system to a world coordinate system via a composite modeling transformation, to a viewing coordinate system via a viewing transformation, to a normalized projection coordinate system via a clipping and view-mapping transformation, to a device coordinate system via a workstation transformation - is longer but is handled more efficiently than in GKS. However, VDI and VDM interfaces with PHIGS will be very similar to those with GKS. Clearer definition of DoD requirements for a graphics language standard, based on test applications of CORE and GKS, would facilitate directing PHIGS development toward CALS objectives. At the present time, however, significant active DoD participation in the PHIGS development effort would provide limited benefit.

5.5 <u>Virtual Device Interface</u>. GKS, CORE, and PHIGS all have a high degree of device dependence, even though concepts such as workstation definition facilitate program portability. VDI (CGI) will address this problem by providing a major device independent segment coupled with a small set of device dependent drivers, which may someday be incorporated on a peripheral or host hardware connector. The device independent portion of VDI will provide a set of command primitives similar to (but simpler than) those provided by GKS; hence, simple graphics could be developed using VDI alone in a program that would operate faster than the same program written using the higher-order GKS language. VDI also encourages subsetting, with classes of required and optional functions, and an inquiry capability to identify a particular device's incorporated function subset. However, few graphics programs will actually be written with VDI alone, because of its intentional language limitations (eg, the absence of segmentation and viewport manipulation). DoD's principal concern with VDI, the draft of which is being prepared for initial review in 1985, should be the extent and manner of interfacing a higher level graphics language such as GKS with VDI, as well as the potential problems associated with development of VDI device drivers.

5.6 <u>North American Presentation Level Protocol Syntax</u>. NAPLPS is a neutral data exchange format for graphics and supporting text that may provide a vehicle for transmission/presentation of digitized technical documentation used for training or maintenance aids, especially in a static (non-interactive) environment. Since ASCII is a subset of NAPLPS, even SGML-coded text could be transmitted as NAPLPS-compatible data.

Like IGES, NAPLPS is a device independent standard requiring system-unique translators. And, like IGES, it has widespread user support. There, most of the similarity ends. Despite some troublesome deficiencies and ambiguities (discussed in paragraph 5.6.2), NAPLPS is a nearly complete standard. Through its overlay structure of control sets and graphics sets, it provides almost total representation of text and graphics data, including user-definable commands. This same structure makes it easily extensible to new classes of entities, such as the widely-desired addition of sound and speech representation, or the T-code (telesoftware) proposal now being considered by ANSI, without loss of compatibility. Because it was specifically designed for transmission efficiency within the Videotex market, with its band width limitations, NAPLPS was designed to produce extremely compact code. On the other hand, IGES was designed functionally for optimum support of its entity command structure, and is extremely voluminous even in binary transmission format. (Human readability of the IGES file was described as one of the advantages of ASCII-formatted IGES Version 1.0.) NAPLPS translators do not face quite the same magnitude of validation problems that IGES translators must contend with, because NAPLPS command primitives in the Picture-Description Instruction Set are much more simplistic than most IGES entities. The Canadian government has already developed a semi-official set of test data, and NBS is working with the Canadian Department of Communications to improve this test data and develop an automated testing facility. The principal translator problem NAPLPS faces is the tendency of vendors to implement translator subsets as NAPLPS use gradually expands into lower-cost, limited capability hardware applications. Another problem - which more widespread use of NAPLPS will help to resolve - translator incompatibility in the handling of text data. The seven-bit and eight-bit versions of NAPLPS do have slightly different coding conventions, but this is not considered a major problem. More significantly, NAPLPS is only a presentation-level standard; it includes neither session level rules (to handle switching between seven-bit and eight-bit modes, for example), nor application level rules (to control neutral format file storage and retrieval). A bit stream of NAPLPS data can be passed between two systems, assuming both have the necessary session-level decoders, but a NAPLPS file created by one system may not be directly legible by the other system. On the other hand, IGES is defined as a file structure, with record structure and ordering for ease of handling. A NAPLPS file could be translated for storage in VDM format, although it is not clear how difficult or cumbersome this would be.

5.6.1 NAPLPS Structure. The main feature of NAPLPS is its overlay structure, which facilitates extensibility. The 128-element character codes for seven-bit NAPLPS, or the two sets of 128-element characters for eight-bit NAPLPS, are partitioned into control sets and graphics sets, each of which is intended to be re-defined under user control. Hence, to extend NAPLPS for sound

generation would merely involve establishing another set of definitions for the user to invoke. The control sets provide transmission or terminal control, identify the in-use graphics set, define macros, etc. The graphics sets provide text character definitions, picture descriptor instructions or drawing primitives, Prestel-compatible mosaics, macros, and user-definable characters or fonts. Seven-bit NAPLPS uses shift-in/shift-out op codes to exchange graphics sets. Eight-bit NAPLPS uses the eighth bit to represent the graphics set directly, saving both storage space and transmission time. However, seven-bit NAPLPS is the more common implementation, since the current principal NAPLPS applications operate over voice grade telephone lines, using asynchronous seven-bit transmissions. After its overlay coding structure, the next most important feature of NAPLPS is its resolution and color independence. NAPLPS uses a bit-mapped virtual screen, and coordinate system, in which positions are specified in fractions of a 1x1 unit screen. Each coordinate byte specifies a three-bit x-axis fraction and a three-bit y-axis fraction. Precision is increased by adding a second (or greater) coordinate byte. The NAPLPS translator applies the transmitted coordinate fractions to whatever pixel resolution is provided by the display hardware. Color resolution is achieved by a similar technique of increasing or decreasing the depth of the bit plane with one or more bytes of data. (Raster graphics also generally uses a multiple bit plane, but NAPLPS offer a more powerful capability by indexing color coordinates to a color table, rather than specifying them absolutely.) The maximum display and color resolution possible with NAPLPS far exceeds current practical hardware capability; most current translators and development software do not bother to even attempt implementing this full capability. Graphics using the NAPLPS drawing primitives employ either absolute or relative positioning, incremental (chain) encoding for compact storage of irregular line shapes, independent positioning of drawing point and text cursor, and user definition of drawing attributes such as stroke width and texture. Macros can be nested, although NAPLPS does not (yet) provide the features of a true programming language such as DO loops and conditionals. Translators can tailor NAPLPS implementation to suit user needs, such as size of macro storage, and pre-cutting (fast, but resolution constrained) or on-call cutting (slower, but more precise and compact) of user-defined character templates.

5.6.2 Shortcomings of NAPLPS. NAPLPS has several content deficiencies, most of which could be remedied through appropriate extensions, and some of which (such as data storage and retrieval) are remedied through application level programming. Although NAPLPS is intended to be used for on-line, real time data transfer, its design reflects a batch mode, sequential processing mind set. Animation in NAPLPS is often called "blink animation," because each frame is built stepwise and is destructive of the previous contents of the video map; to show movement, an entire frame must be re-transmitted and re-translated, which

can be very slow, even for terminals operating at high clock speed. NAPLPS provides for user definition of macros, which are transmitted only once, stored in a holding area outside the video map, and called at will. But there is no corresponding stack storage to hold and recall attributes which may be temporarily changed when the macro is invoked. For text, there is no standard character font definition, and although NAPLPS allows for proportional spacing of text, there is no standard proportionality algorithm. Hence, a line breakpoint as computed by one translator may be different than that computed by another. Although NAPLPS handles both text and graphics transmission, its principal text application is for graphic (ie, visual) display of formatted text, not document processing in the sense for which a language like GenCode is used. It also lacks a standard roundoff algorithm, which can affect proportionality and relative position calculations for low-resolution display of graphics created using high-resolution precision.

5.7 Virtual Device Metafile. VDM (CGM) provides a neutral file storage and transmission counterpart to the VDI device independent graphics language. Hence, it satisfies a deficiency in NAPLPS - that is, a device independent file storage structure - while at the same time providing VDI and GKS compatibility. As with other so-called "device independent" standards, VDM requires system/language unique translators that write to, and read from the neutral, transportable VDM file. The VDM standard describes seven classes of data, which provide file descriptors and defaults; picture controls, format descriptions, and attribute interpretation modes; drawing primitives and attributes; device and system escapes; and *non-graphic* message/text and other data. VDM's text handling capability provides better user control than NAPLPS, but VDM remains primarily a graphics file standard. Data can be stored in a VDM file in clear text, character encoded, or binary form, providing a range between human-readable but voluminous, and very compact storage. Although these features offer an advantage over NAPLPS, the latter's proven utility, and hence its broader support, make VDM's future unclear. Except for file structure standardization and GKS compatibility, just about everything VDM does can be done as well by NAPLPS. VDM will have to prove itself in the marketplace; DoD can influence that decision, but lacks adequate information to express a preference at this point in time. DoD should support further development and demonstration of both standards until the strengths and weaknesses of each for defense applications have been explored.

5.8 SGML/GenCode Structure. The SGML standard defines a text processing language which would be used to implement a generic document coding structure. The generic coding structure, which has been trademarked as GenCode, is the conceptual heart of SGML. The accompanying text processing language is the recommended technique for efficient implementation of GenCode, but GenCode can be implemented on most vendor-unique text processing systems, through the use of specialized translators. GenCode

(or, more properly, the document markup metalanguage) is technically independent of its implementation, and a system can be "SGML compatible" if it employs the markup metalanguage of SGML/GenCode, but not the remainder of the standard SGML text processing language. GenCode identifies the textual elements and hierarchical structure of the document through a set of user-customized codes, called generic identifiers, which follow specified rules of grammar. These codes can then be used to invoke output formatting tables which are applied by the text processing language to translate the marked-up document into a specific form for a particular output application - for example, changing type fonts, page margins, placement of footnotes, or indentation rules. Under the SGML/GenCode concept, a document consists of blocks of data separated by the appropriate markup codes. This facilitates the incorporation of graphics or other "non-standard" data into a mixed mode document by using special markup codes that open and close the non-standard sections. The SGML text processing language must provide the GKS bindings that would facilitate the creation of graphics data to be included in these non- standard sections. The text processing language in the SGML standard is specifically intended to provide these bindings. However, the SGML standard does not specify the physical structure in which the document is stored or transmitted.

5.8.1 <u>SGML/GenCode Application</u>. The markup metalanguage, whether it is called SGML or GenCode, is comprehensive yet flexible; it can be tailored to specific applications, and is already in use within DoD for preparation of technical documentation. Users report that it provides more than enough capability for this application. Some users find it slightly difficult to use because its "raw data" form lacks the familiar page image format of WYSIWYG (what you see is what you get). Some users report success in using standard word processing equipment for "quick and dirty" text keyboarding without SGML tags. Word processing control codes are software-stripped, after which tagging is done by a small group of SGML specialists. In this way, volume input of technical documentation can be accomplished quickly, easily, and less expensively. Certain applications are probably less appropriate, however; an example would be an on-line, interactive training system where text presentation is highly dependent on the processing language itself. Even here, GenCode would provide a system-independent method for initial creation of the training material itself, prior to its incorporation in the particular output application (the training system). Once transferred to the output application, the text data segments delineated by generic markup codes would be completely reorganized for storage in the training system's knowledge base.

5.9 <u>Problems in Graphics and Text Merger</u>. The preceding paragraphs have focused on the strengths and weaknesses of individual standards, as well as comparisons between those which accomplish the same or similar functions. An equally significant

problem, with a very limited experience base and numerous unknowns, is the use of several complementary standards to merge CAD/CAM graphics and text data into a single technical document. These issues can be illustrated by example. This simple hypothetical example involves producing a technical document consisting of a narrative discussion of a product, illustrated with line art from the CAD design of the product, and supplemented by a parts list sorted and formatted in non-standard form. The following sections point out some of the questions implicit in attempting to apply these graphics and text standards to this example.

5.9.1 SGML/GenCode. The essential problem is that of integrating graphics data into the text stream. SGML simplifies this problem by providing the capability for mixed-mode assembly of text and graphics into a single data stream. However, if any of the narrative is extracted from text entered directly into a CAD workstation which does not support SGML, then there must be a capability to extract the text from an IGES General Note entity (or a proprietary text editor/processor) and insert the appropriate SGML markup codes. Similarly, once the parts list data has been extracted from an IGES file sorted, and reformatted using separate application software, SGML must access and incorporate the intermediate parts list file.

5.9.2 IGES. The CAD design, created by a proprietary system, must first be translated into IGES format for transmission to the authoring system. For the sake of the example, however, it is assumed that the illustration will be abstracted from the full design, meaning that some of the CAD graphics must be deleted, along with much of the annotation and part of the structural entity data. At the same time, the parts list data must be extracted from the appropriate IGES entity (which will not exist, except as a General Note, until the release of PDES), and reformatted. The entire product must be compacted into a storage format small enough for efficient inclusion in the text document. Some of this might be done as an ancillary product during the CAD design process. However, most of it - including image extraction/enhancement and data compaction - would be accomplished at a graphics workstation subsequent to the CAD process.

5.9.3 VDI (CGI). The role which VDI would play in this process is primarily a function of the hardware interfaces in the authoring system's text/graphics equipment configuration. VDI would not be required to read in the IGES formatted graphics source data, and VDI's low level graphics commands would be completely inadequate to handle the image extraction/enhancement requirements posed by this example. VDI, while useful, would not be needed at all in a dedicated system specifically constructed for data interfacing such as this.

5.9.4 GKE/CORE. One or the other of these higher level graphics languages would probably be needed to prepare the illustration for incorporation in the technical document. This might include image enhancement, addition of background, etc. Two-dimensional GKS would undoubtedly be the preferred language in this example. However, application software would be needed to translate the IGES source data into a format the GKS/CORE program could manipulate.

5.9.5 VDM (CGM). The compacted graphics data, plus the narrative text and parts list data, must be stored in some format. If NAPLPS is not used for data transmission, then a VDM file format would be the preferred choice for storage, and VDI would be used to facilitate a GKS/VDM interface. Alternatively, a GKS metafile could be used for storage, if GKS were used for image enhancement. If NAPLPS is used for transmission, then a proprietary storage format might be used, or the NAPLPS translator might generate a VDM-formatted data file.

5.9.6 NAPLPS. The role of NAPLPS in either this example or the more generalized text/graphics transmission problem is a function of several factors. ASCII characters are a subset of the complete NAPLPS standard; hence, a NAPLPS translator can be used for transmitting SGML-coded text even if none of the other NAPLPS graphics capabilities are used. But the intended use (e.g., presentation vice simple data handling), the mix of text and graphics, the need for compact volume, and translation problems all need to be considered. Although some authors have proposed NAPLPS as a universal data exchange format, this concept is not completely accepted. It is also possible that NAPLPS would only be used for high volume, long distance data transmission, where data compression is a more significant issue. Direct transmission could be used to pass SGML text streams and VDM or GKS metafile data files among locally networked devices much more simply than would be needed for yet another data translation into NAPLPS code. Certainly long haul communications could also be accomplished without NAPLPS, in which case VDM (and VDI) would be highly desirable for data compaction and equipment interfacing.

Whether NAPLPS is used or not, some form of communications protocol would be required to handle the actual interconnection of various output/display, storage and processing hardware. Here, too, there are unresolved standarization issues, with active competition between proprietary approaches and those compatible with ISO's open system interconnection model. Most major American corporations, and many foreign firms, have adopted approaches compatible with the ISO model and protocols; AT&T and General Motors in particular have done so. However, IBM's System Network Architecture (SNA) is an important de facto competitor. Other proprietary approaches are unlikely to survive, however. The X.400 Messaging recommendations of the International Telephone and Telegraph Consultative Committee (CCITT) also represent an important standardization thrust for local and wide area networking. Issues associated with these topics are particularly

important, not only because of the desire to communicate graphics and text electronically, but because the potential volume of graphics and text data will impose special data handling requirements such as high bandwidth and interactive information handling capability.

6. OPTIONS FOR DOD ACTION. At this point in time, DoD has a wide range of options available for action (or inaction) in the graphics and text standards arena. The Congressional requirement to proceed with development of a technical data locator/index system, the consequent accelerated plans for automation of engineering drawing repositories, and the internal DoD pressure for cost effective technical data automation does not necessarily mandate action on standardizaton. Thus far, DoD has "accepted" - i.e., recognized - GenCode and IGES; there has been some measure of official DoD support for GenCode adoption - i.e., preferred usage - but relatively less for IGES. Principal supporters for these or other graphics/text standards have been at Service level. Continuing this pattern and taking no new or expanded action at DoD level would constitute the "take no action" option. At the opposite extreme lies the option of active development of complete DoD-standard CAD/CAM, graphics and text software languages, much as was done with Ada.

6.1. Take No Action. This option would allow industry standards to evolve at their own pace, and in accordance with user needs. Lack of a coordinated DoD position suggests that DoD would generally follow the market, rather than lead it. Individual Service actions, such as the Air Force initiative that led to the creation of IGES, would continue, and might have a significant market impact, although - again, like IGES - this impact would probably be slow to materialize. The Military Departments would maintain their present programs to automate individual logistics and technical data functions, such as engineering drawing repositories but, without the emphasis of a coordinating process, there would be limited support for integration and standardization of these "islands of automation." Because there is a requirement to support a transition from current paper-based to future digital information management - meaning a requirement for concurrent maintenance of hard-copy drawings/manuals and new digital data bases - there will be too many competing demands for Service time and resources to focus significant attention on new, even "experimental," issues such as graphics and text standardization. The CALS study has already shown that the Take No Action option has failed to adequately identify, much less satisfy, long-term DoD requirements, and it is unlikely that continuation of this option would effectively remedy this problem, even with CALS study results to guide individual Service programs.

6.2. Adoption Policy and Increased ANSI Committee Participation. A clear expression of DoD preference for one or more standards, signed at Under Secretary or higher level, would not only point a direction for Service implementation actions to follow, but would also send a signal to industry that would

accelerate development of the identified standard(s). This is the path NAVSEA has chosen with IGES. Increased participation by DoD personnel on the ANSI technical working groups which develop these standards would also accelerate development, and provide an opportunity to influence the direction of development. This would have the greatest impact on a standard such as IGES, where major avenues of basic development remain to be exploited. The absence of additional funding, however, would still present a barrier to some of the development efforts which are required; it is not self-evident that this option would be adequate to generate a significant increase in Service funding, or that current/increased funding would be applied toward a common development and implementation strategy. Equally significant is the fact that in some areas there is still no clear choice for the preferred standard; for example, between GKS and CORE for some graphics applications, or between NAPLPS and VDM for graphics data exchange andstorage. In some areas (e.g., IGES, SGML/Gen-Code), this option represents an improvement over taking no action, but is still inadequate to meet CALS objectives; in other areas this option might foreclose an avenue DoD should exploit.

6.3. <u>DoD Funding for Development and Demonstration Projects</u>. Under this option, DoD would target funding for development and test/prototyping of appropriate industry standards. This option would offer an opportunity to compare standards where applicability or preference is unclear, as with CORE and GKS in the training environment. Equally important, it would offer an opportunity to accelerate standards integration, such as the problem of data transfer from CAD/CAM to automated authoring systems. This major area of CALS interest would otherwise continue to trail the standards development process, as it has heretofore. Under this option, demonstration projects and development efforts (which would include test/validation) would be undertaken and managed by individual Service project offices, with review and limited coordination at OSD-level. This would allow targeting of funds into high leverage CALS thrust areas, without necessitating direct hands-on management by OSD. It would also facilitate interservice planning and coordination, as well as use of the new DoD Software Engineering Institute, DARPA, and other federal agencies such as NASA and the Department of Energy (which are major IGES supporters), for joint efforts in furtherance of overall DoD objectives for CALS. The two principal benefits of this option are accelerated (and more coordinated) development of standards meeting DoD needs, and implementation follow-through - that is, practical application of the standards in a field environment where utility and limitations can be adequately explored. It would also provide a vehicle to define changes and extensions to the standards, identify necessary and sufficient subsets of features, and test proposed applications. The principal shortcoming of this option is its implicit deferral of an expressed DoD preferance for a particular standard, which might delay action by industry to prepare itself to meet eventual DoD requirements for use of these standards.

6.4 <u>DoD Structure to Guide Development and Implementation</u>. The use of funding controls and project review/coordination provides one approach to channeling Service actions toward satisfying overall CALS objectives. The establishment of a more formal structure, such as a technical steering committee, or a lead Service project office, would offer an even stronger mechanism. Made up of the principal government and industry technical experts and users, a steering committee could develop and coordinate implementation of a detailed plan of action leading to both completion and adoption of the best mix of graphics and text standards for DoD. Meeting regularly to review progress on the implementation actions which they are individually responsible for, the members of such a committee could guide requirements definition within DoD, and could participate collectively in the industry-wide development of the standards themselves. A formally constituted committee would focus effort and attention in a fashion the "normal" organization structure could not. Participation of industry representatives in such a committee would help to ensure that DoD actions proceed in concert with those of industry and the applicable standardization bodies. Shortcomings include committee management bureaucracy and the potential for self-perpetuation. A lead Service project office, supported by technical advisors from other DoD components and industry, could provide an even stronger focus for coordinated development of an overall DoD strategy. By virtue of a continuing, full-time commitment, ideally under a direct mission charter from OSD, a project office could pursue CALS standardization objectives with greater coherence and emphasis. While such an approach could be expected to produce more positive results than a steering committee structure alone, it would require dedication of manpower resources over and above what would be required to manage a program of similar breadth (though lesser depth) through either the committee approach or the standard organization structure approach.

6.5 <u>Mandate Usage of Relevant Standards Within DoD and for New Defense Contracts</u>. This option, the effects of which were explored early in the CALS project, would present industry with a clear DoD commitment to the mandated standards. Some of the potential problems posed during the CALS review could be avoided by being more selective in the choice of standards mandated, providing a longer transition period with exceptions and escape clauses, and accepting the requirement for DoD funding of some or all of the additional costs incurred by industry in complying with the requirement. Except where a clear preference for a well-defined standard has already emerged, such an action by DoD would likely provoke a measure of opposition, both among the Military Departments and from industry. And except where the standard is complete, such a commitment by DoD would entail technical risk which could be difficult to justify on the basis of the substantial, but as yet unquantifiable, long-term economic benefits that are potentially available.

6.6 Develop and Publish Separate DoD Graphics and Text Standards. Under this option, an activity or activities within DoD would undertake the development of MIL-STD documents which satisfy DoD requirements for a standard, integrated product definition, graphics, and text language, including data exchange formats. Although such an undertaking would presumably build on one or more existing industry (nongovernment) standards such as SGML and IGES, it could theoretically develop a completely new approach. Although obviously a massive and time-consuming undertaking, such a course of action is at least technically feasible. It has the advantage of being able to confront directly the known and supposed deficiencies of existing industry standardization efforts, and of avoiding some of the delays which those standards are experiencing as they proceed through the national/international review and approval process. This option is most attractive in those cases where the current proposed/existing standard is incomplete, since it offers a vehicle whereby a single complete language and/or data exchange format could be established for use across Service lines within DoD, as well as among defense contractors, and between contractors and government. However, the obstacles to adopting this option are monumental, and the benefits are not sufficiently well quantified. Although it may be both necessary and appropriate to develop interim supplementary DoD standards as unique DoD requirements become more clearly defined (e.g., incorporation of logistics data entities in IGES), a completely separate DoD effort cannot be justified at this point in time.

7. RECOMMENDATIONS FOR DOD ACTION. The preceding discussion makes it clear that no single option is adequate to address the range of graphics and text standards in which DoD has an interest. It is equally clear that neither of the two extreme options - taking no action, or taking totally independent action - is a viable choice for any of these standards. The principal conclusion that can be drawn, and the resulting principal recommendation, is that the unresolved issues associated with graphics/text standardization are sufficiently complex that some type of formal DoD management structure, such as a project office, should be tasked to pursue a plan for implementing selected standards, actively supporting further development efforts, and managing a mix of studies and demonstration projects to address the questions posed in this paper.

7.1. Principal Findings. With respect to the product definition, graphics, and text standards discussed in this paper, the following conclusions have been reached:

a. SGML and GKS are sufficiently close to formal approval, and widely enough accepted in industry, that a formal DoD commitment to their use should be made. However, issues such as a DIF interface and the GKS/CORE choice for three-dimensional graphics must still be addressed, and an implementation transition period must be allowed for both DoD and industry.

b. Increased DoD activity, including funding of selected demonstration projects, could accelerate development of several standards which have the potential for satisfying DoD and industry needs. This includes VDI, VDM (including resolution of the choice between VDM and NAPLPS), PHIGS, and IGES. This is particularly true in the case of IGES, which is the accepted standard for exchanging CAD/CAM product definition data, but which requires considerable additional development, including identification of development priorities.

c. Time will be required to develop, tailor, validate, adopt, and implement the complete family of graphics and text standards needed to satisfy DoD requirements. Digital data exchange cannot and should not be held in abeyance until these actions have been accomplished. Data exchange using proprietary formats, interim or partial standards, or program-peculiar specifications should be encouraged until such time as the necessary standards are in place.

d. Tests and demonstration projects are needed to resolve questions of standards applicability to DoD requirements. For example, although GKS appears to be the graphics language standard of choice for most automated authoring system applications, a three-dimensional standard such as CORE may be more suitable for selected applications, such as training material or maintenance aids. The ability of NAPLPS to adequately handle volume transmission of text and graphics data among automated authoring systems should be tested; in this context, the applicability of VDM should be explored.

e. No graphics or text standard is totally device independent, not even those such as VDI and SGML which are intended to satisfy this criterion. For some, such as IGES, the development and validation of translators is a major obstacle to widespread use. DoD must be prepared to make a significant contribution of time, funds, and other resources to address this problem if early successful application of these standards in weapon system acquisition programs is to be achieved.

f. The biggest largely unexplored area which must be addressed to satisfy CALS objectives is the interfacing of standards, such as the use of IGES data (or "abstracted IGES" data) as input to a GKS-based graphics subroutine embedded in a GenCode/SGML file. Prior to the beginning of the CALS project, applications such as this had been given only limited consideration. Both the theory and the practice of this issue require considerable additional attention, beginning with some controlled tests, followed by a series of substantive demonstration projects.

g. Graphics and text standards alone are not enough. Communications protocols, data base management standards, neutral query languages, and other standarization issues must also be addressed.

h. For a significant period of time DoD will have to function in a transitional mode. Old, paper-based logistics and technical data must be maintained; some will be converted to digital form through both standard and non-standard means, but (usually) only on an as-needed basis, for conversion is costly and resource intensive. New data will not all be delivered in digital form, for industry is also in a transitional mode, albeit further advanced than DoD.

7.2 Recommendations. Based on the above, the following recommendations for DoD action are made:

a. DoD should establish a Project Office in one of the Services to manage a CALS Standardization Implementation Program. Actions undertaken as a part of this program would be accomplished through a mix of direct effort by the Project Office, contractual support acquired through a budget administered by the Project Office, and support provided by each of the Services and coordinated by the Project Office.

(1) The Project Office should be operated by one of the Services, under a direct OSD charter. A Technical Advisory Group including representatives from the DoD components, selected other federal agencies (such as NBS, DOE, NASA, GPO), and defense industry associations, under OSD chairmanship, should review and coordinate the Project Office's plans and programs.

(2) The Project Office would participate in development and maintenance of CALS-related industry (non-government) standards through membership in the appropriate ANSI and ISO technical committees. A DoD-internal coordination group, perhaps modeled on the Data Exchange Committee established by General Motors to guide and control IGES implementation within GM, should be established to link the CALS Project Office, the Military Departments and Agencies, and OSD at the working level. Through this coordination group, interfaces with the Defense Standardization and Specification Program (DoDD 4120.3) as well as all CALS-related projects would be maintained.

(3) The Project Office would define, justify, and manage expenditure of logistics R&D funding required to accomplish the CALS Standardization Program.

(4) The Project Office would directly manage, or participate in the management of pilot/demonstration programs, and would review and coordinate on full-scale Service implementation programs (such as DSREDS/EDCARS, ATOS, etc.). Through its coordinating function, it would also serve as a de facto architectural control board for individual Service-developed CALS architectures, as well as their interfacing across Service lines.

(5) The Project Office would coordinate development by the Services and LOGDESMAP of DoD-unique, CALS-related standardi-

zation programs such as development of an acquisition logistics data element dictionary (in MIL-STD-1388-2A, or elsewhere, as appropriate) consolidating data requirements in MIL-STD-1388-2A and other Military Standards, revision of DIDs to facilitate neutral-formatted digital delivery of data, preparation of handbooks and training materials, etc.

(6) The Project Office would prepare a Military Standard for management of CALS information transmission and access. This standard would define requirements for hardware compatibility, software and data exchange transparency/portability, communications and delivery media, and data base/network access for technical data packages and engineering/logistics data prepared in accordance with standards such as MIL-STD-1388-2A or DoD-STD-100C.

b. DoD should announce its adoption (not merely acceptance) of SGML for all technical documentation text processing functions, and GKS for all two-dimensional technical documentation graphics functions, with the earliest practical implementation. An incentive program should be developed which would encourage defense contractors to make a similar commitment. A phased implementation program should be developed for application of these standards both within DoD, and for contractor-developed material.

c. DoD should announce its intention to actively promote the development and implementation of IGES for product definition exchange through incentive programs, funding of demonstration projects, and formal validation of translators. Although it is premature for DoD to fully adopt IGES, DoD should exploit every opportunity to incorporate IGES compatibility wherever possible for digital delivery of CAD/CAM product definition or engineering drawing data. DoD should announce now its intention to adopt IGES following release of the "new" Product Definition Exchange Specification by the National Bureau of Standards. As an interim measure, DoD should publish an IGES entity schedule to encourage (but not enforce) contractor compliance with the current/soon-to-be-released versions of IGES. This schedule should be patterned on that established by NAVSEA, which in turn was based upon the IGES compliance schedule that General Motors is imposing upon its CAD/CAM vendors.

d. Through active participation in ANSI/ISO technical committees and funding of research studies, DoD should support and accelerate development of industry standards as follows:

(1) Major emphasis - Development of IGES to:

(a) incorporate logistics data in PDES.

(b) develop translator validation procedures, and develop test data for Version 2.1/3.0 and PDES.

(c) accelerate or initiate further extensions for a new "PDES Version 2.0" including: geometry and product definition data for electronics and printed circuit boards, electrical cables and harnesses, and hydraulics; product definition requirements for manufacturing processes other than machine shops; incorporation of CAE tools.

(2) Medium emphasis - Standards Interfacing. (Rationale: This area is accorded less-than-major emphasis as a standards development effort because it is perceived that the most significant accomplishments in this area will emerge as a by-product of CALS pilot/ demonstration projects which apply, but are not aimed specifically at developing, interfacing standards.) Specific thrust areas include:

(a) IGES, VDM (CGM), GKS, SGML.
(b) NAPLPS, SGML
(c) DIF, SGML.
(d) Use of various communications protocols (such as GM/MAP, ETHERNET, IBM/SYTEK) for transmission of standard format text/ graphics data files.

(3) Minor emphasis - Development of other text and graphics standards. (Rationale: These standards are already under active development. DoD can accelerate that development, but is not yet in a position to define substantive differences in required content.) These include:

(a) Three-dimensional GKS
(b) VDI (CGI)
(c) PHIGS

e. Through active participation in ANSI/ISO technical committees and continuing funding, DoD should support research and development of communication protocols (especially bridging), intelligent gateways, network topology, distributed data bases, hardware/software transparency, and neutral data bases and data base management systems. Although not directly related to graphics/text standardization, these issues all must be studied to most effectively exploit digitized delivery of graphics and text data. Among the related topics which should also be explored are access control and security for classified or proprietary information; traffic characteristics, data volumes, and resource requirements for CALS-related data; interfaces and demands to be placed by CALS on the Defense Data Network; techniques and auditability for data base updates; and the relative

efficiencies of horizontal or vertical partitioning, or redundant storage within a distributed system.

f. DoD should seek wherever possible to apply text, graphics, and product definition standards in both demonstration projects and full-scale implementation programs involving digital delivery and retrieval of weapon system acquisition and support data. These demonstration projects would be aimed at exploring the full range of hardware, software, and telecommunications technology, plus the contractual and managerial policies/procedures needed to satisfy overall CALS objectives. The use of standard languages, data exchange formats, or communication protocols should be viewed as one important element of a complete demonstration project, although not necessarily as the principal focus of the project. Second, these demonstration projects should also be aimed at defining alternatives and options for management of acquisition logistics data, from which new requirements for standards development may emerge. Examples include:

(1) Digital transmission, first by tape and later electronically, of CAD data from multiple subcontractors for on-line integration with next-higher-assembly CAD data at a prime contractor, followed by transmission/application in a CAM environment, digital transmission/storage at a government drawing repository, and on-line retrieval by a maintenance or engineering activity.

(2) An automated authoring system electronically linked to a CAD/CAM system for technical illustrations with on-line update capability and electronic delivery of technical documents to depot and intermediate maintenance, or wholesale/retail supply organization.

g. Demonstration projects and full-scale Service implementation programs such as the above are already underway, or planned, including many of the elements of a successful CALS strategy. Examples include DSREDS/EDCARS, ATOS, NTIPS, ICAM, RAMP, IDS, etc. CALS funding should be applied to accelerate them, expand their application, and redirect them where appropriate toward objectives such as end-to-end (weapon designer to manager/user) system integration, fully automated near paperless data exchange, and improved application of the automated data by weapon system designers, manufacturers, managers, and maintainers. These programs, as well as new demonstration projects specially designed to explore CALS-related issues, should be used as test beds to develop further recommendations concerning digital data exchange standardization. Among the open questions which need to be addressed are:

(1) Specific entity limitations of IGES for different classes of weapon components, subsystems, etc.

(2) The limitations of two-dimensional GKS vice three-dimensional CORE for use in development of interactive training systems and maintenance aids.

(3) Requirements for new data compression techniques and data exchange standards to support high volume electronic transmission of engineering drawings, technical manuals, and other CALS data.

(4) The adequacy and utility of NAPLPS for transmission of technical data for maintenance support or other logistics functions.

7.3 Implementation Schedule. The initial action undertaken by the new CALS Project Office should be development of an implementation roadmap and milestones for the actions listed above. The following tentative milestones appear reasonable, assuming that a dedicated staff is available for their support:

(1) By June 1985 -

(a) Establish a Technical Advisory Group and publish a coordinated Action Plan.

(b) Begin active participation in ANSI/ISO technical committees.

(c) Announce DoD adoption of SGML and GKS.

(d) Publish IGES entity schedule and DoD position statement supporting development of IGES/PDES for 1986 adoption.

(2) By December 1985 -

(a) Publish CALS information management Military Standard, as described in subparagraph 7.2a(6).

(b) Assure inclusion of logistics entities in PDES. Complete IGES translator validation procedures, a full test data set for Version 2.1/3.0 and a preliminary test data set for PDES, and undertake validation of existing IGES translators for ten major CAD/CAM systems.

(c) Preliminary resolution of standards interfacing issues, including demonstration of IGES/SGML and DIF/SGML interfaces.

(3) By December 1986 -

(a) Announce DoD adoption of PDES (Early 1986).

(b) Through NBS, support publication of a draft "Version 2.0" of PDES addressing electronics and printed circuit boards, expanded manufacturing applications, and language interfaces.

(c) Complete validation of all available IGES translators.

(d) Publish results of all of the demonstration projects described in subparagraph 7.2f (digital delivery and retrieval of CAD data, and automated authoring).

7.4 Conclusions. Standardization of graphics and text languages and data exchange formats offers significant potential for improvements in weapons system acquisition and logistics support. However, these standards are incomplete, and only SGML and GKS are nearly ready for full adoption by DoD. Most require additional development, and all (including SGML and GKS) need additional attention to interfacing and validation. DoD can make a major contribution to completion and industry-wide implementation of these standards, while at the same time advancing CALS objectives, by committing manpower and funding to development, validation and demonstration of these standards. Additional work is needed to define the details of these actions and identify the level of funding support needed. NBS's recent three-year, $5 million research proposal provides an overview of the text/graphics standards research and development efforts needed, but does not provide for the near-term actions that DoD should take for maximum benefit. DoD should move promptly to better define these requirements and proceed on an accelerated schedule to implement a program of graphics and text standardization.

LOGISTIC SUPPORT CONTRACT ANALYSIS

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H. J. Correale

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Arlington, VA 22209

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Rm. 3E187, The Pentagon
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Technology Division
Defense Logistics Agency
Room 3C442, Cameron Station
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OASD, A&L/SS
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OASD(MI&L)SPM
Rm. 2C263, The Pentagon
Washington, DC 20301

Bruce Lepisto 1
1400 Two Skyline Place
5203 Leesburg Pike
Falls Church, VA 22041

OSD/WHS/DIOR 1
ATTN: Mrs. Karen Kirkbride
1215 Jefferson Davis Highway
Suite 1204
Arlington, VA 22202

DoD-IDA Management Office 1
1801 N. Beauregard Street
Alexandria, VA 22311

Defense Technical Information Center 2
Cameron Station
Alexandria, VA 22304-6145

Department of the Army

Mr. Eric Orsini | 1
Deputy Assistant Secretary
of the Army (Logistics)
Rm. 3E620, The Pentagon
Washington, DC 20310

Edwin Greiner | 1
Assistant Deputy for Materiel
Readiness, AMC
Room 10S06
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

Fred Michel | 1
Director, Manufacturing Technology
HQ AMC, ATTN: AMCMT
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

Richard Callan | 1
HQ AMC, AMCRE-C
Room 5E08
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

Mike Ducody | 1
HQ AMC, AMCRE-C
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

John E. Holvoet | 1
HQ AMC, AMCMT-S
Room 8N14
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

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HQ AMC
AMCSC-PLD
5001 Eisenhower Avenue
Alexandria, VA 22333-0001

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USAMC
Material Readiness Support Activity
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Lexington, KY 40511

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AMC - ALMSA
210 N. Tucker Boulevard
P. O. Box 1578
St. Louis, MO 63188

LTC Steve Tracy 1
HQ U.S. Army
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Washington, DC 20310

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AMMRC, DRZMR-M
405 Arsenal Street
Watertown, Maine 02172

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Army Materiel Command AMCRE-C
5001 Eisenhower Avenue
Alexandria, VA 22333

Department of the Navy

Emerson Cale 1
Deputy Director for Logistics Plans
Chief of Naval Operations
Room 4B546, The Pentagon
Washington, DC 20250

Dave Sherin 1
Director, Logistics R&D
NAVSUP 033
Room 606, Crystal Mall 3
Washington, DC 20376

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NC3, Room 6W44
PMS 309
NAVSEA
Washington, DC 20362-5100

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NAVSUP 033
Room 606, Crystal Mall 3
Washington, DC 20376

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Director, Aviation and Ordnance Programs
Department of the Navy
120 Crystal Plaza 5
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Arlington, VA 22202

Albert S. J. Knight, II 1
Computer Integrated Engineering
Branch, Code 936
Naval Ocean Systems Center
San Diego, CA 92152-5000

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Navy Surface Weapon System
Engineering Station
NAVSEA Data Support Activity/5H13
Port Hueneme, CA 93043

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PML 550
511 Crystal Square 5
Washington, DC 20376

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PMS 309
6W44 National Center 3
Naval Sea Systems Command
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AFALC/CCX
Wright-Patterson AFB, Ohio 45433

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Deputy for Supply and Maintenance
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Washington, DC 20250

COL Donald C. Tetmeyer 1
AFHRL/LR
Bldg. 190, Area B
Wright-Patterson AFB, Ohio 45433

Nick Bernstein 1
AFWAL/FIBR
Building 45
Wright-Patterson AFB, Ohio 45433

Neil Christianson 1
AF/RDXM, Engineering Data Standards
Room 4E317, The Pentagon
Washington, DC 20250

Mr. Gerald Shumaker 1
AFWAL/MLTC
Wright-Patterson AFB, OH 45433

Terry Granger 1
AFALC/PTL
Wright-Patterson AFB, Ohio 45433

COL Hondo Hernandez 1
Ass't. DCS/Product Assurance
and Acquisition Logistics
HQ Air Force Systems Command
Andrews AFB
Washington, DC 20330

Kenneth L. Morris 1
AFALC/PTAA
Wright-Patterson AFB, OH 45433

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AFHRL/LR
Area B, Bldg 190
Wright-Patterson AFB, Ohio 45433

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AF/XOXIM
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Mr. William Bohaning HQ AFLC/LMS Wright-Patterson AFB, Ohio 45433	1

CAPT Paul Condit 1
AF/HRL
Wright-Patterson AFB, OH 45433

COL Robert Frank 1
HQ AFLC/LMS
Wright-Patterson AFB, OH 45433

Ms. Mary I. Grafton 1
HQ USAF/LEXW
Rm. 4B333, The Pentagon
Washington, DC 20330-5190

Other Government Agencies

Mr. Bernard G. Lazorchak 1
Joint Committee on Printing
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Warren Michigan 48090-9010

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Fran DeLaura 1
Mitre Corporation
1820 Dolley Madison Blvd.
McLean, VA 22102

Mark Geppson 1
Honeywell, Inc.
Mail Stop MN 15-2694
P. O. Box 312
Minneapolis, MN 55440

Laurie Andrews 1
P. O. Box 19422
Burbank, CA 91510

Michael Garverick 1
International Business Services, Inc.
1090 Vermont Ave, N.W.
Washington, DC 20005

James J. Sikora 1
Vice President, General Support
Test and Evaluation
BDM Corporation
1801 Randolph Road
Albuquerque, NM 87106

Mr. Richard Biendenbender 1
Evaluation Research Corporation
1755 Jefferson Davis Highway, Suite 800
Arlington, VA 22202

Mr. E. B. Birchfield 1
Chief Program Engineer,
Computer Aided Design
McDonnell Aircraft Corporation
P. O. Box 516
St. Louis, MO 63166

David H. Wilson 1
MIS IR-15
Boeing Aerospace Company
P. O. Box 3999
Seattle, WA 98124

Mr. Hal Resnick 1
QUSOFT, Inc.
Suite 206
2755 Hartland Road
Falls Church, VA 22243

Mr. Lee Rivers 1
Hughes Aircraft
Building A-1, M/S 4C617
P. O. Box 9399
Long Beach, CA 90810-2399

Mr. H. I. Starr 1
TRW Electronics and Defense
Building 119B, Room 4005
One Space Park
Redondo Beach, CA 90278

Mr. Robert Vermette 1
American Management Systems
12th Floor
1777 North Kent Street
Arlington, VA 22209

Mr. Michael Long 1
American Management Systems
12th Floor
1777 North Kent Street
Arlington, VA 22209

Robert L. Annett 1
Marine Division (ML&H)
Integrated Logistics Support
Westinghouse Electric Corporation
P. O. Box 499
Sunnyvale, CA 94088

Donald L. Seidenspinner 1
Systems Engineering, Integrated
Logistics Support
Grumman Aerospace Corporation
Bethpage, NY 11714

Doug Doerr 1
ITT Aerospace/Optical Division
P. O. Box 3700
Ft. Wayne, IND 46801

John C. Gebhardt 1
Vice President, Engineering and
Research
InterCAD Corporation
2525 Riva Road
Annapolis, MD 21401

Thomas L. Nondorf 1
Senior Engineer, Logistics
McDonnell Aircraft Company
P. O. Box 516
St. Louis, MO 63166

Richard Gunkel 1
IDA Consultant
President, BITE, Inc.
9254 Center Street
Manassas, VA 22110

Mary A. Klement 1
Group Engineer, ILS Engineering
General Dynamics
Convair Division
P. O. Box 85357
San Diego, CA 92138

Richard Alweil 1
Director, Product Engineering and Support
Hazeltine Corporation
Cuba Hill Road
Greenlawn, NY 11740

John Barker 1
Director, Product Support
Boeing Aerospace Company
P. O. Box 3999, Mail Stop 82-09
Seattle, WA 98124-2499

Jack N. Best 1
Corporate Director, Productivity
Programs and Plans
General Dynamics Corporation
Pierre LaClede Building
7733 Forsyth Street
St. Louis, MO 63105

Howard Chambers 1
Vice President, Logistics
Rockwell International
North American Aircraft Operations
100 N. Sepulveda Boulevard
Dept. 101-ZT-12
El Segundo, CA 90245

Harley Cloud 1
Director of Technology
IBM Federal System Division
6600 Rockledge Drive
Bethesda, MD 20817

Herman Correale 5
Corporate Director, Product Support
McDonnell Aircraft Company
Lambert Field
Dept. 090, Building #1, Level 3
P. O. Box 516
St. Louis, MO 63166

Darrell Cox 1
Rockwell International
North American Aircraft Operations
201 North Douglas Street
Dept. 118,011-GC02
El Segundo, California 90245

W. R. Phillips 1
Vice President, Enginering
Newport News Shipbulding and Dry Dock
4101 Washington Avenue
Newport News, VA 23607

Mike Deeter 1
Manager, Advanced Logistics
North American Aircraft Operations
Rockwell International
100 N. Sepulveda Boulevard
El Segundo, CA 90245

John Dutton 2
Director, McAir IRM
McDonnell Aircraft Company
Dept. 52, Level 1, Room 380
6951 N. Hanley
Hazelwood, MO 63042

George Fredericks 1
Manager, Logistics R&D Engineering
IBM Federal Systems Division
Mail Stop 864/5A58
1100 Frederick Pike
Gaithersburg, MD 20879

James A. Palmer 1
Director, Engineering Administration
Newport News Shipbuilding and Dry Dock
4101 Washington Avenue
Newport News, VA 23607

Mark P. Pittenger 1
Boeing Aerospace Company
20403 68th Avenue, South
Kent, WA 98032

John Tierney 1
Director, Logistics Requirements
General Dynamics Corporation
Fort Worth Division
P. O. Box 748, Mail Zone 1835
Fort Worth, TX 76101

John Willis 1
Rockwell International
100 N. Sepulveda Boulevard
Dept. 115-GD-10
El Segundo, CA 90245

John Anderson 1
Boeing Aerospace
P. O. Box 3707, Mail Stop 03-80
Seattle, WA 98124

George Beiser 1
3001 N. Florida Street
Arlington, VA 22207

Ray Bourn 1
IBM Federal Systems Division
Mail Stop 102-072
9500 Godwin Drive
Manassas, VA 22100

Robert R. Brown 1
Hughes Aircraft Co.
Bldg. E-1, Mail Stop A116
P. O. Box 902
2000 E. El Segundo Boulevard
El Segundo, CA 90245

William E. Florance 1
Eastman Kodak Company
Advanced Systems Division
Bldg. 601, Kodak Park
Rochester, NY 14650

Gary L. Foreman 1
Senior Scientist, Advanced Program
Support Lab
Hughes Aircraft Co.
Bldg. 276/Mail Stop T42
Canoga Park, CA 91304

Judson French, Jr. 1
Program Manager, Advanced Development
Support Systems
Westinghouse Electric Corp.
Mail Stop 7034
1111 Schilling Road
Hunt Valley, MD 21031

Siegfried Goldstein 1
Siegfried Enterprises
7 Dulittle Street
North Babylon, NY 11703

Erich Hausner 1
Lockheed California Co.
Dept. 72-78 90-3 A-1
Burbank, CA 91520-7278

Fred Hirt 1
Litton/Mellonics
Suite 8206
490 L'Enfant Plaza East, SW
Washington, DC 20024

Frank M. Krantz 1
Westinghouse Electric Corp.
P. O. Box 1693, Mail Stop 4410
Baltimore, MD 21203

W. D. Lewis 1
General Dynamics Corporation
DSD Headquarters
12101 Woodcrest Executive Drive
St. Louis, MO 63141

Fred Macey 1
Dept. 63-11, Zone 333
Lockheed Georgia Co.
Marietta, GA 30063

Mark Palatchi 1
Dept. 63-11, Zone 333
Lockheed Georgia Co.
Marietta, GA 30063

William W. Tunnicliffe 1
Graphics Communications Association
1730 N. Lynn Street, Suite 604
Arlington, VA 22209

Warren Mathews 1
Corporate Vice President for Product
Effectiveness
Hughes Aircraft Co.
Bldg. C-A, Mail Stop B195
200 N. Sepulveda Boulevard
El Segundo, CA 90245

Bob Gulcher 1
Vice President, Research and Development
Rockwell International
Dept. 101-GB-08
P. O. Box 92098
Los Angeles, CA 90009

Jack Osborn 1
Structural Dynamics Research Corporation
2000 Eastman Drive
Milford, OH 45150

Patrick M. Dallosta 1
Logistics Engineering Associates, Inc.
P. O. Box 3357
Annapolis, MD 21403

R. Thomas Moore, Jr., CPL 1
Vice President, Operations
Logistics Management Engineering, Inc.
P. O. Box 3318
Annapolis, MD 21403

SYSCON Corporation
1000 Thomas Jefferson St., N.W.
Washington, DC 20007

ATTN: Pat Moore 1
Georgetown Division
4th Floor

Jim Stemple EDS Crystal Square 2 Suite 912 1725 Jefferson Davis Highway Arlington, VA 22202	1
James D. Moroney Midwest Manuals, Inc. 1 West Interstate Street Bedford, OH 44146	1
J. William T. Smith Systems Management Engineering Corporation 1054 Cedar Ridge Court Annapolis, MD 21403	3
Dick Fleeson Consultants and Designers 1725 Jefferson Davis Highway - Plaza Level Arlington, VA 22202	1
Floyd Hutzenbiler BDM Corporation 10260 Old Columbia Road Columbia, MD 21046	1
Mr. Robert Nemmers General Electric Company 12030 Sunset Hills Road Reston, VA 22090	1
Donald G. Buxton Assistant Program Manager for Integrated Logistics Support TRW, Inc. 7600 Colshire Drive McLean, VA 22102	1

Other

Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311	
S. Deitchman	1
R. Pirie	1
W. Schultis	1
V. Utgoff	1
J. Grotte	1
P. Goree	1
F. Riddell	10
C&D	137

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